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REPORT ON THE INTERNATIONAL METEOROLOGICAL CONFERENCE, HELD AT PARIS, SEPTEMBER 17 TO 23, 1896.

BY WILLIAM ELLIS, F.R.S.

[Read November 18, 1896.]

THE meetings of the Conference were held at the offices of the Société d'Encouragement, Rue de Rennes. The number of members attending the various meetings was in all 44. These were—

MM. Angot,
Anguiano,
Baillaud,
Becquerel,
von Bezold,
Biese,
Billwiller,
Chauveau,
Dufour,
Ellis,
Erk,
Fines,
de Fonvielle,
Fron,
Hepites,
Hergesell,
Hildebrandsson,
Jaubert,
Kesslitz,
de Konkoly,
Lancaster,
Mascart,
Mathias,
Mohn,
Moureaux,
Neumayer,
Page,
Paulsen,
Riggenbach,
van Rijckevorsel,
Rotch,
Rücker,
Rykatcheff,
Schmidt,
Scott,
Snellen,
Stupart,
Symons,
Tacchini,
Teisserenc de Bort,
Thévenet,
Tolnay,
Watzoff, and
Wragge,

some few of whom, not representing institutions or societies, were invited as guests.

At the first meeting, on September 17, Mr. Scott, representing the International Meteorological Committee, opened the proceedings by proposing as President, M. Mascart, who had filled a similar office at Upsala, a proposal unanimously adopted. MM. von Bezold and Tacchini were elected Vice-Presidents, and MM. Angot, Erk, and Scott Secretaries. The Minutes of Proceedings were drawn up and printed in the French language, and the discussions were in French, but communications in English and German were also received.

Mr. Scott read the Report of the International Meteorological

Committee. He said that owing to Dr. Wild having been compelled through ill-health to resign the position of President of the Committee, it had devolved upon him to give an account of the proceedings of the Committee since the meeting at Upsala in 1894. Two points only of the report need here be noted. The Committee at the Upsala meeting having discussed the question of obtaining facilities for the transmission of international meteorological telegrams, and passed a resolution thereon, a copy of this resolution was sent in 1895 to M. Billwiller, for communication to the International Telegraphic Bureau, in order that it might be submitted to the Telegraphic Conference to be held at Buda-Pesth in the present year. Further, in regard to the question of the measurement of the heights and velocities of clouds, a circular had been sent to meteorologists generally, asking whether they were prepared to take part in the proposed system of cloud observation; and to those assenting so to do, a second circular was sent to ascertain whether they would be willing to carry on the work until August 1, 1897, in order that observations should extend over 15 months instead of 12. Numerous favourable replies were received, some particulars in regard to which will be presently mentioned.

The Conference appointed Committees to consider definite classes of subjects as follows:—(1) Terrestrial Magnetism and Atmospheric Electricity; (2) Clouds; (3) International Telegraphic Service; (4) Meteorological Instruments and Methods of Observation. The conclusions of the Committees were reported to a general meeting and, with slight modification, adopted.

I may at once say that the questions discussed by the Committee on Terrestrial Magnetism and Atmospheric Electricity find no place in this report, so far as terrestrial magnetism is concerned. It may, however, be mentioned that they were numerous and of considerable importance. As regards atmospheric electricity, M. Chauveau spoke of the registration of electricity on the Eiffel Tower, submitted photographs relating thereto, and asked the Committee to support and promote the study of atmospheric electricity. A resolution was adopted recommending the employment of self-registering apparatus for observation of atmospheric electricity.

At the meeting of the Committee on Clouds, M. Hildebrandsson submitted a report from the chiefs of the meteorological services of different countries, from which it appeared that regular observations are being made in Sweden, Norway, Denmark, Russia, Finland, France, Belgium, Prussia, at Pola, in the United States of America, Switzerland, Würtemberg, at Strassburg, in the Netherlands, at Manilla, and at Batavia. Observations are to be commenced next year in Hungary, and preparations are being made for observations in India. Observations will probably also be undertaken at Sydney. I am unable to give any complete list of the actual stations in each country, but may mention that usually several observations, and in some cases many observations, are made daily. The system employed is not the same in different countries, but this probably is not of such importance so long as observations on some sufficient system are really in progress. As at many stations observations for 12 months will not have been made at the end of the period originally fixed at Upsala—May 1, 1896, to May 1, 1897—(afterwards extended, as mentioned, to August 1, 1897), a resolution was adopted expressing the desirability of continuing the observations at secondary stations until the end of the year 1897, or five months longer than last suggested. It was further proposed that the International Committee should appoint a new Committee on Clouds.

The deliberations of the Committee for considering the question of the acceleration of meteorological telegrams are mainly of interest to the officers of meteorological services in different countries. It is therefore sufficient to say that the Committee resolved that the best way of establishing international meteorological relations would be to promote a circular system (*un système de dépêches circulaires*) at a fixed hour between central offices. It was further considered desirable to make a trial of the system, limiting it to a few contiguous countries.

This disposes of the subjects considered at Committees, excepting those (a considerable number) referred to the Committee on Instruments and Methods. In speaking of the remaining questions discussed, I shall not distinguish between the deliberations of this Committee and those of the Conference, but go through the questions of the programme in the order in which they appear on the paper, merely saying what may seem necessary to indicate sufficiently the manner in which each one was dealt with.

Two questions remained over from the Munich Conference of 1891. The first was that of Mr. Symons on the subject of establishing in each country one or more double meteorological stations for comparison of the local system of each country with an uniform international system to be decided upon at a Meteorological Conference. To facilitate discussion of the question Mr. Symons circulated a printed statement explaining the reasons that had led him to make the proposal. The question resolved itself into one of comparison of methods of thermometric exposure; Mr. Symons modifying the proposal by recommending that at each selected station, in addition to the ordinary equipment, two other thermometer stands should be erected similar to those of any two other countries, to include maximum and minimum thermometers and hygrometer, and that the readings of the three sets of instruments be taken for two consecutive years, and the results published in full. Considerable discussion ensued. It was finally resolved that at one station at least, in each country, in addition to the ordinary thermometer stand, other methods of exposure shall be simultaneously employed, the forms selected being the Stevenson screen, the French stand, and the aspiration arrangement of Assmann, the latter to be in any case employed. Observations to be made for two years, and, if they cannot be published *in extenso*, then for each month the means and the extreme values should at least be given. It was considered equally useful that in each country an uniform pattern of stand should be adopted, of which a complete description should be published with sketches, such as would enable the stand to be exactly reproduced.

The second question standing over from the Munich Conference was that of the consideration of methods of extending meteorological observations and publications in the interests of agriculture. In reply to a circular issued by Mr. Scott, as Secretary to the International Meteorological Committee, after the Upsala meeting, a number of individual reports on the subject were received, and printed in the appendix to the Report of the Upsala meeting. No general report having been made to the Paris Conference, the question was postponed to a future Congress.

The Conference then proceeded to discuss the special questions proposed for consideration at the Paris Conference.

The first was one by Dr. Schreiber, proposing that the meteorological day should be reckoned from 9 p.m. to 9 p.m., meteorological extremes to be taken and rain measured at 9 p.m., as the close of the meteorological day. Mr. Scott, pointing out that this question having been decided at the Vienna Congress in 1873 by the adoption of the civil day, said that it seemed unnecessary now to modify that decision. Mr. Symons having expressed a similar opinion, the Conference proceeded to the next question.

This was one by Prof. Watzoff, drawing attention to several different methods of calculating daily means from hourly observations, and asking whether it was not desirable to recommend some one method for adoption. He instanced three methods as being at present in use: (1) in which the mean of the 24 hourly values 1 to 24 was taken; (2) in which the mean of the 24 hourly values 0 to 23 was taken; and (3) in which the mean of the 25 hourly values 0 to 24 was taken. M. Angot said that it seemed difficult to adopt either formula, the only accurate formula being $(\frac{0+24}{2} + 1 + 2 \ . \ . \ . + 23)$ divided by 24, an expression not more troublesome to calculate than the others. I pointed out that the methods (1) and (2) were only objectionable as not representing the civil day ending with midnight; that is to say, (1) applies to a day ending half an hour after midnight, and (2) to a day ending half an hour before midnight, whilst (3) is arithmetically wrong, the method instanced by M. Angot being the only one by which, from hourly values, a daily mean for the 24 hours ending precisely with midnight can be obtained.

The third question was one recommending that commencing with 1901 the solar magnetic period of 26·67928 days should be employed as the natural mode of classifying meteorological phenomena, solar, physical, and terrestrial. M. von Bezold considered this question as not ripe for discussion, and proposed to remit it to a future Congress, to which the Conference agreed.

Dr. Schreiber proposed certain changes in the manner of classifying days of rain, on which Mr. Scott, referring to the resolutions on this subject adopted at the Congress of Vienna in 1873, and at the Conference at Munich in 1891, proposed to abide by the decisions arrived at on those occasions.

Mr. Rotch then introduced the question standing in his name as to whether the rule established by the Congress of Vienna that the symbol for thunderstorm is only to be employed when lightning and thunder are both observed, should strictly be followed. After considerable discussion it was resolved (1) that the symbol ᴛ be added to the International Symbols adopted by the Congress of Vienna to indicate days on which distant thunder is heard; and, in conformity with the Congress of Vienna, that (2) the symbol < shall be reserved for distant lightning and sheet lightning; and that (3) the signal K shall indicate all cases in which lightning is seen and thunder heard; also that (4) in summaries the number of days in each of the three cases shall, as far as possible, be separately given.

On the subject of the registration of bright sunshine, one proposed by our Society for discussion, I handed in a statement recording the attention given to the subject in our country, mentioning amongst other things that a daily register had now been maintained at a considerable number of stations for some fifteen or more years, the total number of stations existing in the United Kingdom now in regular work being more than seventy. Referring further to the circumstance that two instruments of different character are in use, the Campbell-Stokes instrument, registering bright sunshine, and the Jordan instrument, registering possibly something more than bright sunshine, and considering further the fact that some fifteen of the instruments in use are of the Jordan type, the necessity for an authoritative comparison of the two instruments had become apparent, which comparison I was enabled to say that Mr. Dowson, of Geldeston, had voluntarily undertaken to make, he having already commenced the work which was to be continued for one entire year. I alluded also to the necessity for similarity of interpretation of the records, adding that discussion of the observations of the Campbell-Stokes instrument had already yielded results of great interest as regards the distribution of sunshine throughout the United Kingdom. A memoir by M. Koenig was also submitted. Mr. Scott considered that certain differences found by M. Koenig between the Jordan and Campbell-Stokes instruments were due to some defect of adjustment of the latter, the spheres of glass not having all the same focal distance. A considerable discussion ensued in which the necessity of maintaining records of bright sunshine, the difficulty of registering the duration in countries in which the sun attained only a low altitude, the importance of registering also intensity, and other points became reviewed. M. Rykatcheff recommended the use of the photoheliograph of M. le General Welitchko, with which he said that traces could be obtained very near to the horizon. The Conference adopted a resolution enforcing the necessity of placing the sunshine instrument in a position from which the horizon was entirely visible, and directing that, in the formation of the percentage of the possible amount of sunshine, the number of hours should be referred to the total apparent duration of the day. Finally, on the proposition of M. Snellen, the International Meteorological Committee was asked to appoint a special Committee for the study of solar radiation.

On the question of uniformity and extension of observations on infiltration into the soil, proposed by our Society, some discussion ensued, in which, although the importance of the subject was acknowledged, it was felt that, in the present condition of the question, it did not appear possible to adopt any formal resolution.

The Conference now proceeded to discuss four questions relating to wind measurement. Two of these were proposed by our Society, one being that of the general adoption of a standard velocity anemometer, and the other that of uniform exposure. The two other questions, by Prof. Sprung, had reference to the correction and reduction of anemometrical records. I handed in a statement pointing out what had been done in late years by our Society, mentioning that the Society some years ago appointed a Wind Force Committee to investigate experimentally the question of the measurement of wind velocity and force, and that amongst other things the Committee had promoted such work as the comparison of observations of wind force in Beaufort's scale with the records of neighbouring anemometers, the testing of anemometers of different forms on a whirling machine, the comparison of anemometers one with another, and other similar work, mentioning also that the extensive series of whirling experiments made in connection therewith had been carried out by Mr. Dines, whose study of the questions involved had led him to contrive new forms of anemometers, briefly describing the principles of his helicoid, pressure plate, and tube anemometers, and adding some remarks on the accordance therewith obtained. MM. von Bezold and Hergesell gave explanations concerning the Recknagel anemometer, and proposed the adoption of this instrument. Mr. Scott said that the experiments of Mr. Dines were not favourable thereto. After further considerable discussion, it was proposed by M. Mascart that the Conference does not consider it possible at the present time either to recommend any particular form of anemometer as standard, or any identical method of exposure for all stations, to which the Conference agreed.

In regard to the question also proposed by our Society, concerning uniformity of conditions under which observations of earth temperature should be taken, no resolution was adopted. The study of the question was recommended, and it was considered desirable that a report upon the subject should be prepared for the next Congress.

M. Angot desired to add two new symbols to the international system, one to indicate days on which rain not measurable had fallen, and one to indicate haze (*la brume*). M. Rykatcheff further suggested the adoption of a symbol for a particular form of hoar frost (*le givre*), but after observations from other members, both propositions were withdrawn.

M. Mohn read a communication on the possibility of determining the pressure of the air by the hypsometer (boiling-point thermometer) with sufficient accuracy for meteorological purposes. The Conference thanked M. Mohn for his communication, which will be printed in the appendices, but took no action thereon.

Dr. Billwiller advocated the necessity of introducing an uniform method of reducing barometric readings to sea-level for the construction of synoptic weather charts. After discussion, the Conference recommended that the directors of the different meteorological services should consult together upon this question.

The Conference considered that a question by Dr. Schreiber, calling attention to the development and extension of observations of sea temperature in the North Atlantic Ocean, was one that did not call for any definite resolution, seeing that the importance of extending observations at sea did not admit of any doubt.

M. Snellen read a communication upon the use of the telemeteorograph of Olland, describing it as working in a satisfactory manner between Flushing and Utrecht, and recommending a more extended use of the instrument. M. Lancaster mentioned that nearly twenty years ago the telemeteorograph of van Rysselberghe was in effective operation for nearly two years between Ostend and Brussels, but that the use of the instrument had to be discontinued owing to the great expense of the telegraphic communication.

Four questions dealing with points concerning cyclones and cyclonic movements of the atmosphere now came under consideration, in three of which the Conference were asked to determine absolutely certain matters in connection therewith. This the Conference felt it beyond their power to do. The fourth question, having reference to the establishment of international researches into the meteorological conditions around cyclonic centres, was considered to be one in which extension of observation was evidently desirable.

M. Paulsen presented monthly charts showing the variations in the distribution of floating ice in the Atlantic Ocean north of the parallel of 60°. The charts he said were not complete, but he considered that it would be of great importance to meteorology if such charts could be continued, and made more complete. After some remarks, it was resolved that the Conference highly appreciates the scientific value of the work undertaken by M. Paulsen, and expresses the wish that meteorological institutions in communication with navigators in the seas north of latitude 60° would be pleased to communicate to M. Paulsen such observations as they may receive.

At the meeting of the Conference on September 22, Mr. Symons proposed that the new International Meteorological Committee should consist of the same members as before, with the substitution of the name of Mr. Russell for that of Mr. Ellery, of Prof. Willis Moore for Mr. Harrington, and of M. Rykatcheff for Dr. Wild. This being adopted, the members of the new Committee thus are:—

MM. von Bezold,
Billwiller,
de Brito-Capello,
Davis,
Eliot,
Hann,
Hepites,
Hildebrandsson,
Mascart,
Mohn,
Moore,
Paulsen,
Russell,
Rykatcheff,
Scott,
Snellen, and
Tacchini.

At a special meeting of members of the Conference interested in aeronautical work, it was resolved that, recognising the great importance to meteorology of balloon observations, scientific ascents should be encouraged and extended. Other resolutions referring more to details of the work were also adopted, one to the effect that, seeing the satisfactory results obtained at the Blue Hill Observatory by the use of kites carrying registering instruments, it is desirable that similar observations should be undertaken elsewhere.

By resolution of the Conference, on the initiative of M. Snellen, the International Meteorological Committee was invited to convoke a meeting of directors of meteorological services interested in maritime meteorology, with a view to establish uniformity in methods of observation and publication, and it is hoped that a report upon the question may be presented at the next Conference.

M. Mohn, referring to M. Nansen's collected meteorological and other observations made between latitudes 81° and 86°, promised to do his best to reduce and publish all these observations according to the methods adopted by the Meteorological Congresses and Conferences.

M. Hildebrandsson presented to the Conference a copy of the *International Cloud Atlas*, on which the President, M. Mascart, expressed to MM. Hildebrandsson, Riggenbach, and Teisserenc de Bort the hearty thanks of the Conference that this work had been brought so soon to a successful termination.

M. Mascart, referring to the decision come to at Munich, that the Conference should meet at the end of five years, asked whether, similarly, the next meeting should take place again in five years, that is in 1901. This was agreed to, it being left to the International Meteorological Committee to select the place of meeting.

Mr. Wragge proposed at different times a number of questions in addition to those appearing on the printed programme. Some of these were held to be covered by questions already on the programme, and others to be of a character that did not admit of the Conference expressing an opinion without appearing to reflect on the action of other governments. The most important of his questions were: one with reference to the desirability of carrying on meteorological observations on the summit of Mount Wellington, in Tasmania, which, in southern latitude, has the same altitude as Ben Nevis. M. Neumayer supported the proposition, and the Conference considered that the station would be scientifically a valuable one, and that it would be useful to publish *in extenso* the hourly observations; another similar question was that of establishing a meteorological observatory also on the summit of Mount Kosciuszko at the south-eastern extremity of Australia, a position which the Conference considered would likewise be a valuable one. Mr. Wragge further asked the opinion of the Conference on questions having reference to the possibility of predicting the weather in Australia for considerable periods in advance, but on these the Conference, whilst appreciating the work of Mr. Wragge, were not prepared to offer any opinion.

M. Mascart was asked to accept the office of President of the International Meteorological Committee, Mr. Scott retaining that of Secretary. It was further reported that Sub-Committees had been appointed as follows:—

(1) Terrestrial Magnetism and Atmospheric Electricity.
(2) Aeronautical Questions.
(3) Radiation and Insolation.
(4) Cloud Observations.

All with power of co-opting other members.

M. Mascart, in terminating the meetings of the Conference, thanked the foreign meteorologists who had come in such numbers to the Paris Conference. Favoured by their co-operation he could say that the success of the Conference had been complete: the meetings had been numerous and well attended; the discussions had been of great interest, and important resolutions had been adopted. He hoped that the remembrance of this amicable meeting would induce the greater part of the foreign members to return to Paris on the occasion of the Universal Exhibition of 1900.

M. Tacchini proposed that the foreign members should return their hearty thanks to M. Mascart and all the French members of the Conference for the manner in which they had been received.

The meetings of the Conference, at which the discussions throughout had been marked by the most amicable feeling and good temper, were thus brought to a conclusion.

DISCUSSION.

The President (Mr. E. Mawley) said that the thanks of the Fellows were due to Mr. Ellis for so ably representing the Society at the recent International Meteorological Conference at Paris, and also for the very complete account he had given them of the various questions that had been discussed on that occasion. When they, as a Society, placed such a high value upon strict uniformity of observation, it could not but strike the Fellows as strange, and at the same time as disappointing, that the advances made in that direction on such occasions should be, as a rule, so slight, and that notwithstanding the many practical suggestions put forward by our British representatives.

Capt. D. Wilson-Barker said he wished to endorse the President's remarks as to the desirability of uniformity of method in Meteorological observations. He thought that there should be a compromise all round to attain this object, which was of such great importance to the determination of Meteorological laws.

Mr. G. J. Symons remarked that this was his first experience at an official International Meteorological Conference, and he was not disposed to rate the business done very highly; but, of course, there was no doubt that the free intercourse between the Meteorologists of the different countries must be productive of much good to the science. In describing the visit to the Eiffel Tower in a gale, Mr. Ellis had omitted to mention the experiments made by the members from the upper gallery with pieces of paper. These behaved in a most eccentric manner, some floating in the air at very various velocities and for a considerable time, thus demonstrating the absence of any uniformity in the currents. Even a felt hat, which was accidentally blown away, travelled nearly a mile before it fell into the Seine near the Pont d'Jena. One of the most interesting features of the meeting was an excursion to the remarkably well-equipped meteorological station established by M. Teisserenc de Bort at Trappes, 18 miles south-west of Paris. Mr. Ellis' services to the Society at the Conference were very considerable, but he was under a slight disadvantage in being an electrician as well as a meteorologist; therefore, when magnetic questions were being discussed in one room and meteorological ones in another, his duties were no sinecure.

Mr. C. L. Wragge said he wished to add emphasis to the desirability of uniformity. In the management of the Queensland weather system he had always adhered strictly to the rules laid down by the Royal Meteorological Society. He knew of only one divergence, and that was that the screens, though of the same shape, were four inches larger every way than the enlarged ones used in this country. He had only lately concluded a tour through Western Queensland and Cape York Peninsula, for the purposes of inspection and the establishing of new stations. On one occasion while at a station named Boulia, near the Northern Territory, a very violent thunderstorm, accompanied by a deluge of rain, came on after a prolonged drought. On visiting the gauge it was found that the water it contained was quite discoloured, showing that there must have been considerable rebound from the hardened ground; and this impressed him with the desirability of raising the level of the rain-gauge from one to two feet above the ground. He should like the opinion of the Royal Meteorological Society as to whether this could be done without sacrificing real uniformity. The grass, too, in coast districts of Queensland grew very rapidly, and many of the observers, who were mostly officials of the Postal and Telegraph Department, had not always the time to keep it trimmed. He had consulted with Dr. Buchan on the subject, and he (Dr. Buchan), though strictly advocating uniformity, thought that in such cases the rain-gauges should be raised to a standard height of two feet, and the reason for so doing fully stated.

The President (Mr. E. **Mawley**), in reply to Mr. Wragge, said he did not think that as a Society they could express any official opinion upon the questions he had raised, but advised him to consult those of the Fellows who had made a special study of them.

Mr. R. **Cooke** thought that a comparison should be made at different stations, with gauges at one and two feet respectively above the ground. This would give an idea of the extent of the error.

Mr. F. **Gaster** asked for some clearer explanation of the information which is to be published with regard to the observations in the different forms of thermometer screens. If we are to be furnished simply with the mean daily temperature for each month, and the absolute maximum and minimum recorded during the month, the values would be all but useless. We want in addition the means of the daily maxima and minima, as recorded in both screens, which will enable us to discover (or rather to impress on all meteorological workers) what is the difference between all the readings as recorded in the different forms of screen.

Mr. G. J. **Symons** said that his original proposal was to have three patterns of thermometer stand at one station in each country, one to be similar to that generally adopted in the country, and the remaining two those of any other two countries. The Conference recommended the establishment of the comparison stations, but did not decide, as he had hoped, that the observations (which are to be made for only two years) should be printed *in extenso*. The object of the proposal was to obtain data showing the corrections required to render comparable records made, say, with a French and a Stevenson screen. At present there are, say, between Folkestone and Boulogne two variables, (1) the difference of climate, (2) the difference due to the mounting of the instruments—until (2) has been ascertained, no one can tell the true value of (1).

HAZE, FOG, AND VISIBILITY.

By the Hon. F. A. ROLLO RUSSELL, M.A., F.R.Met.Soc.

[Read November 18, 1896.]

Haze.

Some years ago I was led to conclude, as a general result of observations during a long period, that the phenomenon of haze, or dry mist, is in the main the effect of a mixture of currents or winds differing in temperature.[1] There were, however, points of difficulty in the proposition of which I could not see the reason until I had examined each in detail, and taken a sufficient number of additional observations with special regard to the questions involved. Most of these were taken at Haslemere 40 miles south-west of London. The first difficulty was the frequent prevalence of haze during a dry North-east wind. Since haze was assumed to be due

[1] See *Nature*, November 22, 1889.

to particles of water, whether deposited on dust or not, it appeared incredible that such particles should form themselves in a dry air to a greater extent than in a damp wind from South or West. We are all too well acquainted with the disagreeable and ugly haze of the North-east wind. Why should this wind, whether cold in winter or hot in summer, whether dry or moist, strong or gentle, so often bring with it an obscuration of the sky and the landscape which seldom attends the humid equatorial breezes? Excess of dust cannot be a chief cause, for there is no reason to suppose that the polar regions or the North Sea yield any extra number of fine solid particles to the air. The North-east wind is often only the northern half of the lower area of a cyclone passing from west to east, or else it may be merely local or temporary in a district; yet in each of these cases we have the characteristic haze, surely without excess of dust. In course of time, by taking note of the direction of upper currents during the prevalence of this wind, I found that whenever the North-east wind was proved to be established to a great height, there was, as a rule, good visibility; and in this case the wind often endured many days: and that, conversely, whenever the lower atmosphere was clear with a North-east wind, this wind, as a rule, prevailed for a long time, and was incidentally seen to extend to a great height. So much does this rule hold good that in winter a clear North-east wind may be taken, independently of cloud observations, to signify endurance and a rather long period of cold. On the other hand, when there was much haze and small visibility, the upper air moved from a Westerly or Southerly direction, and the maintenance of the North-east wind was commonly short. And after observing the clouds coming from a Southerly or Westerly direction, and an ominous calm below, it might be taken as almost certain that any North-east wind ensuing would be accompanied by thick haze.

Thus the North-east wind, which seemed to contradict the hypothesis of a mixture of currents being the cause of haze, in reality gave strong evidence in its favour. Assuming the upper current to be prevalent between 20,000 and 40,000 feet, and to be flowing in a contrary direction to the lower North-east wind, there would evidently be a very large amount of interchange and mixture of the two winds over a large area. The upper limit of a temporary North-east wind is often much less than 20,000 feet, and in such cases a great degree of obscuration may occur in the lower strata, if the temperatures of the two currents differ widely.

The mixture throughout of two fluids of different temperatures is a slow, gradual, and irregular process, taking place quite unequally in different portions of a disturbed mass. Great differences of temperature, quite out of keeping with any general law of decrease with height, occur in a vertical ascent through successive blocks or strata of air, and considerable differences are also noted on the same horizontal plane. Beyond these differences in large volumes, it is exceedingly probable that differences less in amount, but not inconsiderable, occur between small portions of the same block, stratum, or wind. Not only may two winds differ as wholes in temperature, but portions of each may differ to a still greater degree. The contact of such portions, when the winds are mixed, must favour the deposition of vapour. Wherever differing laminæ are coterminous, deposition of vapour may take place upon the particles of dust always more or less present, and very seldom falling below 250 in the cubic centimetre. The condensation may be instantaneous, followed quickly by evaporation; but the continuance of the process in multitudes of particles in every cubic yard will maintain the continuity of obscuration.

A striking proof of the competence of mere mixture to produce haze occurs when a South-westerly air meets a North-easterly air near the ground level, with the result that mixture takes place in the calm zone between them. The haze so produced may be exceedingly dense, and at the same time unusual darkness often covers the area of conflict, giving rise to alarm and anticipations of thunder. In this case the haze formation is in a vertical column or wall of air over a narrow belt of country, instead of being widely spread in horizontal currents. I have often passed through such haze columns and have always found the currents on each side of them to be in opposition; in fact they may be regarded as evidence of a conflict. The intensity of the haze so produced, when the currents differ considerably, is probably due to the directness of impact and sudden condensation, when horizontal currents meet at the same levels, and the darkness will also depend on the height of the column of air in which the currents meet and mix. Sometimes the particles of steam are not only numerous but large, and pass rapidly from a bluish to a pale-brown hue. I believe it will be found to be a general rule that, *cæteris paribus*, the more rapid the mixture of any two currents the larger the particles of water condensed out of them. Occasionally, when opposite currents meet, no haze is produced, and this is when, so far as can be ascertained, they are like in temperature and other conditions, or are both much above the dew-point, or when the warmer air pushes back the cold, while the upper strata are humid, whether clear or cloudy.

Dr. von Bezold has shown that when warm, saturated air is mixed with cooler, the cooler air may be very dry and yet condensation may take place; and that condensation takes place more rapidly when a wedge of cool moist air enters a large mass of warm air than when a wedge of warm moist air is blown into a mass of cool air. The condensation here spoken of very far exceeds the slight dust accretion of thin haze. This haze condensation may result from the mixture of warm unsaturated air with dry cool air.

The haze which often occurs before or during thunderstorms likewise results from the conflict of currents on which the genesis of the storm depends. Thunderstorms are generally caused by gentle, eddy-like disturbances, and by the mixture and lifting of warm, moist air-masses. They continue until one current or the other preponderates.

In confirmation of the above conclusion as to the cause of haze with North-easterly winds, a similar hazing was observed to occur in fine dry weather with a sudden shift of wind from South-west to West or North-west, or from a warm to a colder quarter. Such veerings were often temporary, and no reason appeared for ascribing the decrease of visibility to an increase in the dustiness of the air. Haziness occurred, too, with a mere reduction of temperature, either abnormal, as in the middle of the day, or normal, as in the evening, without any noticeable change of wind. And in general, any increase of haziness seemed proportional not so much to the dustiness or dampness of the air as to influences reducing the temperature of points in the lower strata below that of their immediate environment.

The haze of fine, dry spring and summer weather, with variable airs, is even more puzzling than the haze of North-easterly winds, for it persists for days or weeks, often equally thick through day and night. It is generally bluish-grey by reflection, and causes the sun to appear deep red, shorn of its rays, at rising or setting. Several causes may be somewhat concerned in its production: (1) Excess of dust; (2) loss of heat by radiation. For much excess of dust there appears no sufficient reason, except perhaps the long absence of clouds and rain, which might gather and precipitate it, and dry weather with a light, steady breeze through a great depth of the atmosphere has not the accompaniment of haze, which belongs to the variable currents, although it should be equally dusty. Nor can radiation be the chief cause of this haziness, else it would be much thicker by night than by day, and would mostly disappear under an overcast sky. Mixture of main currents of wind seems a very improbable cause, for the atmospheric conditions are steady, and there are commonly no clouds to indicate disturbance.

But let us remember that the type is anticyclonic, marked by light variable currents or calm, and that the flow of air in the lower levels is downward and outward, not by strong downrushes and outrushes, but by gentle airs and infiltration. We have, in fact, over our islands a mass of air of low humidity, under pressure greater than the mean, pervaded by various horizontal currents and light breezes, and by perpetual downward filaments from a high and cold region. Above the sinking and outward-moving currents of the middle air in the anticyclone, the winds concentrate with a spiral-inward motion from all directions and become mixed as they descend. Then they meet the lower breezes, and in the daytime the ascending currents from heated land; while in the night-time, on the low levels, the strata are cooled by terrestrial radiation. In these encounters there must certainly be mixture sufficient to produce a heterogeneous mass, such as would show, if we could examine it with a sensitive thermometer, rapid thermal changes in successive portions. Yet this air is on the whole dry, so dry that a difference of 8° or 10° may be shown between the dry and wet bulb thermometers.

How can vapour be deposited on dust-particles sufficiently to produce haze hiding the view beyond a distance of six to twelve miles? That it is so deposited seems probable from several considerations: (1) Similar conditions, that is, variable airs with a distribution of pressure generally anticyclonic, produce in winter haze or fog, in which vapour deposition is obvious. (2) Similar conditions, in autumn or other seasons, with contending airs of slight force, and of high humidity, produce widely extended wet fogs, or damp mists, or thick haze, coinciding with the area of mixed currents. (3) Where sudden local reductions of temperature occur in damp winds, clouds are formed of a density proportional to the suddenness of the reduction and to the moisture of the air, and where the reduction is more gradual or caused by mixture with another wind not greatly differing in temperature, haze is formed.

The persistence through day and night of the haze of dry weather with variable gentle airs, tends, in conjunction with the above facts, to show that loss of heat by radiation is not the main cause of deposition, although, no doubt, radiation has much effect both by day and night. Haze often diminishes by the reduction, through the interposition of clouds, of loss of heat by radiation, and increases or persists with almost cloudless skies; on the other hand, thick haze sometimes occurs under a thick canopy of clouds, when radiation as a cause may be neglected. But in all cases, so far as my observations go, there is reason for inferring that a mixture of currents is taking place; and if this factor be absent, other natural causes are generally incompetent to produce a haze in dry weather. When dense haze prevails under thick clouds or cirro-velum, humidity is high, and persistent haze is not common in a dry air under a thickly clouded sky.

We have to account for the deposition of moisture on dust particles in air unusually dry, either with variable airs, or with North-easterly winds of short duration. Water existing in the air at any moment in particles so minute as to give a blue reflection is unstable, and probably cannot maintain itself more than a few seconds. The stage of blue steam between the invisible vapour from a locomotive funnel and the white steam-cloud above is a very short one. The ascent of air which forms clouds is commonly too prompt in reducing temperature to allow us to see the blue stage immediately beneath the clouds, although if the observer carefully compares the visibility at that level, as indicated by distant hills, with the visibility lower in the atmosphere, a bluish haze just under the clouds will be found to be less rare than might be supposed. But how does haze maintain itself? In air below the point of saturation, evaporation disposes of the particles, and in saturated air they usually grow quickly, with exceptions to be noted later, to the size of globules of fog or cloud. In our latitudes, and with our insular position, the air must be thickly permeated by particles of dust, consisting largely of sea-salt, and in some districts carbonaceous and sulphurous particles are also abundant. The saline and sulphurous are hygroscopic, and specially potent in causing deposition of moisture; the carbonaceous are remarkably strong radiators and capable of attaching vapour. In a large area of dry weather, there is reason for excess in the number of these various particles per cubic foot in the lower atmosphere, for in changeable or wet weather they serve as nuclei to clouds and rain, and are concentrated and washed down. And in still weather a more than ordinary number aggregate in the lower levels. There is also reason for an excessive radiation from such particles, with or without an accretion of moisture, for in continued drought the atmosphere is unusually dry to a great height, and there are few clouds to intercept and reflect heat emitted from below. Thus we have all the strata below great heights powdered with more than an average quantity of fine particles of strong radiative and condensing capacity. So long as the air in which they float remains uniformly much above the dew-point, moisture will not condense upon them, and the air will be more than usually transparent, as in fact it often is in fine summer weather. But let rills or filaments of colder air pass intricately through it, and immediately many solid particles cooled thereby will condense vapour upon themselves, for they as radiators keep below the temperature of the contiguous vapour, and as being hygroscopic they attract moisture.

A parcel of warm, moderately dry air, coming in contact and mixing with cold air, falls in temperature and approaches nearer the dew-point; while at the same time some of the cold air recedes further from the dew-point; but the mixture is not so intimate and complete that these changes at once nullify each other. There are moments when some of the floating dust falls below the dew-point, and at these moments contributes to the appearance of haze. The condensation lasts, perhaps, no longer than the faint bluish clouding of a lens on which a breath is blown from the lungs, for in each case the general surrounding air is well above the dew-point. The dew-point of a hygroscopic particle in the high air cannot be the same as the dew-point of our instruments. Salt will gather moisture though the dry bulb may be 2° or 3° above the wet bulb. Radiation is much less hampered under the open sky than near the ground, or houses or trees, not to speak of a Stevenson screen. Instrumental readings tell of great dryness through the effect of wind in rapidly evaporating moisture, but a particle aloft has no wind, only small currents; we must not estimate the distance of the air from deposition by the reading of large dry and wet bulbs under cover and exposed to wind. Delicate dry and wet bulbs under the open sky and carried with the wind would not show so great differences as if fixed under cover near the ground. Minute invisible dust particles may here and there by radiation, even in sunshine, fall to the dew-point special to themselves. Scattered dust particles with a dry atmosphere overhead are probably only very slightly raised in temperature by sunshine. Indeed, we know this to be the case, for we see in spring, winter, and autumn, a layer of fog near the ground, or a bank of fog or cloud, or a streak of thick haze, receiving the full rays of the morning sun and only very slowly yielding and dissipating. Where the particles are not massed in a body, the warming effect of sunshine would be still slighter. Cirrus remains for a long time almost unchanged in form under the mid-day sun in air very much drier than any near the surface of the earth. Yet the intensity of sunshine is far greater at the altitude of cirrus. In a winter frost, when the air is very dry, we may observe another instance of the adequacy of radiation against absorption; the delicate rime on twigs or branches exposed to the sky refuses to melt under the noonday sun, although the temperature of the air be only a few degrees below the freezing-point. Ice-spicules, or small snow-flakes, float down through a sunny air at 32° without losing a feather. Even the surface of snow, or of a frozen pond, may remain intact in dry air a little below the freezing-point. Here the maintenance of the solid state depends very distinctly on the dryness of the atmosphere, for if a South-westerly air supervene at some elevation, the frost quickly gives way.

Now a microscopic particle floating at a height above the ground is still more free to radiate, and less affected by terrestrial warmth than the surface of snow or of a low cloud. On the other hand, it must follow more closely the temperature of the air molecules immediately about it.

Suppose then a mixture of winds to take place, one being 5° colder than the other, and each being 4° above the temperature of saturation. Mixed in equal quantities, their temperature will be 2½° lower than that of the warmer wind before mixture. But there will have been portions in each mass of air, not only of higher and lower temperature than the mean, but of greater and less humidity. Small laminæ of the warm wind may be near saturation, and these, brought into contact with filaments of air 5° lower in temperature, and perhaps only 2° or 3° above the dew-point, will at once condense out some of their vapour on the contained dust.

This explanation may seem somewhat forced, but the character of the dust, as well as the inequalities of the air, supports it. Common experience proves the power of salt to attract vapour from the air when below saturation, and laboratory experiment shows that saline and sulphurous dust bring about cloudy condensation with less cooling than other dusts. Carbonaceous dust, or smoke, gives, in our towns during fine winter weather, almost daily evidence of its condensing property, due most likely to its active emission of rays of heat.

Large differences of temperature have been proved to be common between neighbouring blocks of air, vertically especially, but also sometimes horizontally. It is reasonable, almost necessary, to assume differences of several degrees between neighbouring patches of air when intermixture of different currents is proceeding by filamental diffusion. The condition is beautifully illustrated, on a different scale, by the ascending wreaths and pillars of mist when the morning sun lifts a stratiform bank of cloud from the hillside. The irregular distribution of clouds, and the opacity to sound, several times noticed by Tyndall during fine weather, likewise prove irregularity of conditions. He did not find any increase of sound-stoppage during hazy weather, but this only proves that not every sort of haze is the result of a flocculent condition of the air. Haze, like fog, often shows itself when the air is disposed in horizontal layers near the surface of the earth or sea, and this would favour the transmission of sound. On the other hand, when, as in Tyndall's observations, sound was stopped on fine clear days, the flocculent condition, caused by streamlets of air and vapour of different temperatures, may have existed, yet without giving rise to haze, owing to the dryness and purity of the lower atmosphere, and to feeble radiation.

Haze prevails in those very states when there is reason to believe that the air is heterogeneous, and heterogeneous within small volumes. In anticyclones there *must* be convection or diffusion downwards, else the anticyclonic circulation could not be maintained, as it is, for long periods. In variable airs there is both horizontal and vertical diffusion. In North-easterly breezes of short duration, and sometimes of long duration, there is mixture by friction against the upper current and by the return of somewhat moist air originally equatorial along a sea-surface generally lower in temperature in summer and higher in winter.

My observations show that haze is most common with North-east, East, and North winds, and on turning to the observations of the directions of cirrus cloud in Berwickshire by Stevenson, I find that, in the words of Buchan, "the most frequent direction of the cirrus cloud was from South-west; the North-west was nearly as frequent; the West only a little less so; and any one of these three directions was about equal to all the other five directions taken together." Thus in every case of North-easterly wind, the probability is great that at the same time a Westerly wind is blowing within a very few miles overhead.

Balloon ascents and cloud observations have shown that often the East wind only extends to an altitude of 3000 to 10,000 feet. During the recent prevalence of North wind, October 1896, the higher clouds, when visible, were moving from the South.

When, on the contrary, Westerly winds are blowing, the upper clouds rarely move from an opposite quarter.

The bearing of these facts upon the differences between Westerly and Easterly winds is obvious.

Fog.

The causes of fog are to a great extent the same as the causes of haze, although radiation in certain states of the air and ground plays a more conspicuous part.

The main and most common cause of fog is mixture of airs of different temperatures; and the attainment of a size of water-particle so much larger than in the case of haze is due to (1) suddenness of mixture, (2) greater humidity, or (3) greater differences of temperature.

Radiation often becomes exceedingly effective both indirectly and directly; indirectly by the cooling of the ground and consequent slipping away of the cooled air strata to lower levels in uneven country, or by collection on low levels, or plains, of air cooled by contact with the ground; and directly by the loss of heat of the fog itself radiating into space.[1]

The following are instances of fogs resulting mainly from mixture:—

1. The fogs off Newfoundland and in the neighbourhood of the Gulf Stream, where vapour in air from warm areas of ocean, or of land, mixes with air lying over the cold ocean current from Arctic latitudes; and *vice versâ.*

2. The summer fogs which suddenly invade the English sea-coast from the sea, commonly early in the afternoon. These are moist fogs, light mists, or haze, according to the differences of temperature, etc., over sea and land, and they are caused by the ascent from the land of heated air which passes seaward at some altitude, and then becomes mixed with the cool air over the sea, which forthwith rushes inland to replace the ascended currents. These fogs do not often extend far inland, and, when they do, are raised to some low altitude, where they have the appearance of scud clouds of slight thickness. In fine, hot, calm weather such irruptions are very apt to occur from the North-east, greatly reducing the temperature, and covering the sky with thin clouds driving rapidly before the breeze. These coast fogs are most frequent in the early summer, while the temperature of the sea is still many degrees below that of the air on land.

3. Widely-extended somewhat damp fogs, mist, or thick haze, lasting sometimes for days or even weeks with contending winds, especially North-east and South-west. These fogs reach to a high altitude, and are common. The most persistent and oppressive within my memory were the damp fogs and haze of September 1894.

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[1] When loss of heat by radiation is hindered, as by clouds or by humid air, at a high or low level, the particles do not grow at all, or may not increase beyond the stage of haze. Saturated air also remains clear when the number of dust particles is much below the mean.

4. The fogs of the narrow calm interspace between winds, especially North-east and South-west. With these may be mentioned the damp fog signifying the approach of an equatorial displacing a polar wind; and the fog, either dry or wet, produced by a polar current displacing the equatorial.

5. A very sudden squall of wind from the North-west or North in rainy weather with South-westerly wind may produce a dense canopy of dark mist or fog, often with thick rain or snow. This soon clears away when the cold wind is established.

6. Some of the fogs lying over valleys, water-courses, lakes, and hollows, when the air above is not more than usually dry. These fogs often result from the mixture of local currents, differences of temperature between land and water, the contact of warm air with the cold of the lowest levels, or from the first creeping advance of an invading wind.

Now, as regards radiation fogs, or anticyclonic fogs, which are often spoken of as dry, to distinguish them from fogs which are obviously moist, I have come to the conclusion, after many years' close observation, that these also result largely from the mixture of currents. They arise commonly in air nearly calm, or with gentle currents, and when the ground has been cooled by copious radiation. The calm, and the gentle currents, generally signify either a conflict of equal breezes, or a condition in which air is descending from a height by infiltration. Also the cold ground creates a cold stratum overlying it, known by experiment to be within the fog-cloud very much lower in temperature and fuller of dust particles than the air just above. The fog grows upward, probably chiefly by radiation from the upper surface cooling the air in contact, and by slight movements mixing the layers, precipitating vapour, and so increasing the number of radiating molecules. Carbonaceous particles are very effective in radiation, and being present in vast numbers over cities contribute largely to the creation and maintenance of a fog. By multiplication of points for condensation, they diminish the wetness, while increasing the density, of a fog. Very small particles in a fog give the impression of dryness, for they evaporate before actually touching any warmer surface. Much of a town fog, however, is really dry, consisting of particles of smoke unable to escape upwards, being chilled below the temperature of the clear superjacent air.

The maintenance of dry fogs, and of not a few moderately wet fogs, depends on the freedom of radiation. They are commonest inland, away from the warm influence of the sea, and on low ground or plains, or in valleys, and on the lee side of smoky towns. The drier the air above the lowest stratum, and the more free from cloud, the denser the resulting fog. Commonly, except in the depth of winter, they dissipate in the late morning or afternoon, and grow thickest in the early morning when the ground has become coldest. In large towns the winter sunshine is often inadequate to compensate for the loss of heat by radiation into space from the thickly scattered particles of carbon and water, and the fog remains, continually reinforced by the volumes of smoke poured forth during the daytime. The heat radiation from a strong lamp does not dissipate the particles. In warm rooms they partly vanish, but leave a residue of smoke. At night they soon become purer and inoffensive, proving the rapid subsidence of smoky ingredients.

Dust by itself, and of an ordinary character, and the very fine particles which have been shown to exist in millions per cubic foot of air in rooms where oil or gas is burnt, are incapable of maintaining or increasing fog in a town perceptibly beyond that of the surrounding country. Therefore, if London or Manchester were to burn wood, gas, anthracite, or oil, as fuel, their excess of fogs would disappear, indeed these cities would be likely, owing to their higher temperature, to surpass country districts in immunity. It is visible coal smoke which is the potent feeder of fogs. Continental towns which burn wood have no excess of fogs, nor had Pittsburg, while for a time it depended on natural gas; nor have the towns of South Wales, while they burn anthracite. None of these places, none of the greatest cities which burn wood, maintain fogs, or even thick haze, appreciably beyond those of the surrounding country, but all large towns which burn smoky coal have an excess of fogs and darkness. In the four months, November and December 1885, and January and February 1886, the city of London had only 62 hours of bright sunshine, as against 222 at Kew Observatory. If coal smoke had been abolished during that period, both the City and Kew would have had more than 222 hours of sunshine.

Wet fogs I have always found to be less dense in London than in the country. In these radiation is comparatively weak, and the higher temperature of the town dissipates the water particles, while the smoke particles do not sufficiently cool to induce deposition. Moreover, the smoke does not fall back into a low cold stratum of small depth as in the case of radiation fogs, which so effectually cool down coal smoke emitted from a tall chimney reaching to near their upper limits, that the smoke cannot escape upwards, but returns into the stratum. In wet fogs the circulation of the air is free, and the products of combustion escape, while only a very small proportion of the smoke particles attach moisture to themselves, radiation being non-effective and the fog globules being larger and fewer.

Radiation fogs do not often occur unless there be substitution and mixture of currents. Neither a steady South-west wind, reaching to a high altitude, nor a steady North-east wind not underlying a Westerly or Southerly current, permits the formation of dense fog. The great frost of 1895 was remarkably free from fog, even with the lowest temperatures, owing to the absence of currents of warm or moist winds at any observed level. Freedom from fog may in fact often be taken to signify endurance of prevailing cold weather, with Northerly or Easterly winds. Fog, sometimes accompanied by drizzling rain, is apt, however, to accompany a gradual conquest of the equatorial winds by the polar.

Smoky fog moved by a slight breeze, frequently grows more dense a a little distance from the town of origin, and so does haze. This is owing (1) to cooling and to the gradual weighting of the smoke with moisture as it spreads out; (2) to the smoke tending downwards in its movement, and attaching particles of moisture to itself in passing over grassy tracts where the air is cool and damp; and (3) to freer radiation towards space and towards a cold ground. Mostly, it is in damp weather with a cold gentle air from North-east, that the London fog becomes darkest near the ground at a little distance out, but dark high smoke clouds are common in dry gentle winds from a cold quarter, and sometimes cause considerable gloom at distances from 10 to 60 miles from London.

Large variations of density often occur in neighbouring places and even neighbouring streets, owing to differences of temperature in neighbouring masses of air, to slight eddies, to the natural tendency of contending currents to aggregate contained matter, and, when there are clouds in the sky, to the lesser loss of heat by the fog vertically beneath them. Fog may in this respect imitate clouds, and the temperature is lower, as in clouds, in the fog than in the clear interspaces.

The darkness which sometimes overspreads London at a high level is due to the entanglement of smoke in a low cloud or raised fog, caused by different currents and intensified by ascensional movement. The greatest darkness results from an upward-moving column of smoke and fog over a small area. A gentle breeze bearing a moderate amount of smoke from London, and meeting an opposite current at 30 miles distant, may produce foggy darkness in the neutral zone ; at 40 or 50 miles, thick smoky haze or cloudiness.

Wet fogs occasionally but rarely show abrupt alternations of thick and clear near the ground. By far the sharpest lines of demarcation in the author's experience, so sharp as to cause a horse to shy, were exhibited over a grassy surface by a ground fog in damp and not anticyclonic conditions. The reason of so peculiar distribution is not less obscure than of the sharply-separated, hard-edged and irregular stratiform clouds which diversify the summer sky.

Bands of brown haze, closely simulating smoke, occur somewhat frequently in two conditions; either in exceedingly fine dry weather, with variable winds and shifty land or sea breezes, or in doubtful skies with local showers from high stratiform clouds, and conflicting Westerly and Easterly breezes. In quiet weather the resemblance to smoke is exact. But these bands or streaks of ill-defined haze-cloud never assume the rounded form, and whitish-grey colour, which, seen against the blue sky, unmistakably denotes wind-driven smoke, even at fifty miles from its origin. The brown haze-clouds may be seen at times in the finest weather in all parts of the country, especially in the spring or early summer, and appear often to be connected with differences of land and sea temperature.

Visibility.

The conditions favourable to visibility are dryness of the air near the ground level, uniformity of temperature and moisture, radiation below the mean, steady and homogeneous winds through a great depth of the atmosphere, approximation of the temperatures of sea and land, and a number of dust particles less than the mean.

The first condition is found more generally in the interior of continents than in islands or near the sea, and is the most important factor in visibility. In the neighbourhood of the sea, in most latitudes, high humidity is more frequent, and the quantity of sodium and magnesium chloride in the air is greater; and these two elements in combination powerfully diminish visibility on many days of the year.

High temperature is generally favourable to visibility, for though the absolute humidity is greater, the relative humidity is commonly less than in cold weather or cold climates; deposition does not appear to take place in the air below a certain degree of relative humidity, unless the loss of heat by radiation be very rapid, and this loss is hindered in damp regions by the abundance of water in the atmosphere up to high levels. The distance of the air from that which has a temperature below the dew-point in hot countries much reduces the probability of haze-production by the mixture of currents. And when deposition does occur, the process of growth in drops is rapid, being the result usually of the ascent and expansion of air containing more vapour than saturated air contains in cold climates; sometimes, as in the neighbourhood of high mountains, precipitation results from contact with a current very much lower in temperature.

In winter, when visibility is least inland, the land is colder than the sea surrounding Great Britain and Ireland, and in summer, when sea-fogs and sea-haze are common, and when visibility is greater on land, the sea is colder than the land.

In Great Britain and Ireland, and many other parts of Western Europe, Westerly winds are much clearer than Easterly winds. This clearness depends on the comparative homogeneity of the winds between South and North on the westerly side. With the drier and colder invading air from an easterly quarter, relative humidity must be actually raised, especially in certain minute volumes, and radiation increased, while at the same time a certain amount of adiabatic cooling may occur through the lifting of the Westerly by the lower Easterly wind. Minute portions of the humid equatorial wind, cooled to the particular dew-point in contact with the cold East wind, deposit vapour on the dust, and so produce haze. Steady North-east winds, reaching to a great altitude, are about as favourable to visibility as Westerly winds.

The extreme clearness of Westerly winds is often derived from the effect of clouds and rain in reducing the number of dust particles. And the long passage over the Atlantic Ocean tends to produce a more uniform texture of air than a composition of superposed or variable currents from different quarters, or a passage over varying surfaces of land and sea, such as winds between South and North on the easterly side must travel over. Visibility sometimes increases to a remarkable degree before a day's rain from South or West, and this may be due not only to the diminution of radiation by a high veil of condensing vapour or cirro-velum, but to the diminished number of dust particles in the air preceding the rainy clouds.

Visibility to an extraordinary distance occurs often during a gradual veering of the wind from South to South-west, South-west to West, or West to North-west; while the air grows colder the views open out with great distinctness. After a heavy shower, followed by a shift towards North-west, visibility increases from 25 or 30 to 80 or 100 miles. In some of these cases the transparency of the air cannot be chiefly due to the previous elimination of dust by rain, for often the weather keeps fine, or only a dark cloud, shedding perhaps a few drops, passes over. Probably it results from increasing dryness, from closer agreement between lower and upper currents, and from the descent of pure air from high levels. Curiously enough, the descent of a cold North-east upon a South-west wind produces small rain or clouds or fog, but the descent of a cold

West-north-west or North-west wind soon clears the atmosphere of clouds, rain, or haze. With the North-east wind there is continued clashing and intermixture; with the North-west wind there is quick replacement. In the latter case, if the onrush be rapid, there is a short heavy shower; if slower, a temporary hazing. That clearness depends much on the descent of air from high altitudes seems to be proved by the frequency of a fall of temperature with increasing visibility in windy weather.

London smoke, borne by the wind, often greatly diminishes visibility at 30 to 60 miles distant, and sometimes blots out the sunshine on the finest days.

It is remarkable that of the twelve occasions in 1895 when a visibility of 50 miles or more was noted, not one was during the prevalence of any wind from the eastern half of the compass. And when the visibility was over 22 miles, on 55 days, wind was Easterly on 8 and Westerly on 38 days. On 39 days on which the wind was North-east only 3 gave a transparency exceeding 22 miles, and on each of these occasions the transparency was very brief during a shift from North-east, or else the wind was exceedingly gentle on the hill with a calm on the plain.

I regret to be obliged, owing to limits of time, to defer any detailed account of the results obtained.

DISCUSSION.

The President (Mr. E. Mawley) said that a short time ago a Committee of the Society had attempted to define "fog," "mist," and "haze," but their definitions were not considered altogether satisfactory. This, he thought, need cause no surprise, as all three might be regarded as virtually the same condition of the atmosphere—differing mainly in the size and number of the water-particles it contained at the time. He had often wondered why London continued such a foggy city when its system of surface drainage was so perfect and all the evaporating surfaces were so smooth, but Mr. Russell had explained that this was in a great measure due to the condensation of moisture upon the numerous particles of carbon and other dust present in the air. In this connection he might state that an old inhabitant had recently told him that the fogs in Berkhampstead had increased in frequency and also in density with the growth of the town during the last twenty-five years. If this be correct, which he had no reason to doubt, this increase might be accounted for in a similar way.

Admiral J. P. Maclear said that in South-west Surrey it is commonly remarked that when a wind has Easting in it a certain degree of haze is sure to prevail, but on the shifting of the wind to North-west or South-west it almost directly clears. He supposed that Mr. Russell, when alluding to North-east winds meant those of short duration, as North-east winds of long duration with an upper current from the Westward would be an entirely different condition.

Mr. F. Gaster pointed out that the weak point in the paper was that while ever so many theories or views were presented there were scarcely any facts adduced on which these views were based. This was all very well when observers were scarce, and when their opinions were accepted freely by the outside world; but matters had lately changed considerably, and observers demanded facts, properly grouped, before they could receive the theories which were proposed. In fact no man's *ipse dixit* could be accepted in work of this kind; information must be brought forward to prove the accuracy of any theory which might be offered to meteorologists for acceptance. It would be impossible to go fully into the matter at so late an hour of the meeting, but one or two points might be referred to. Firstly, observations extending over one year are not sufficient to establish any meteorological theory whatever, and in the matter of haze and fog the locality of the observer had to be taken into careful consideration. Secondly, the mingling of currents of wind in an anticyclone is a condition which, as a matter of fact, does not prevail; the currents actually drawing away from one another without mixing at all. Again, the conclusion drawn by the author from the movements of the *cirrus* clouds over Berwickshire is altogether illogical. The proportion of surface winds which blow from the Westerly points is not very different from that of the upper currents referred to, so that, in the absence of facts to the contrary, we have a right to assume that in most of the instances the movements of the surface currents and those at the *cirrus* level may have agreed within a few points, and that in hardly any case is an Easterly surface current accompanied by a Westerly upper current. Such a condition is certainly the exception in the south of England, although it does occur at times, and in those cases the fact cannot account for the development of haze or fog at the earth's surface.

Mr. W. **Marriott** said that when inspecting the Society's stations he had learned that several observers had made notes on the visibility of distant objects. The President (Mr. Mawley), when residing at Addiscombe, kept a record of the visibility or otherwise of the Crystal Palace, which was three miles distant to the north. Mr. F. Amery, of Druid, Ashburton, on the south-east slope of Dartmoor, 584 feet above sea-level, had for many years kept a record of the visibility or otherwise of a tower landmark 17 miles distant to the south-east, which stands on the sea cliff about 400 feet above sea-level, at the entrance to Dartmouth Harbour. Mr. Amery had favoured him with the dates on which the tower was strongly visible to the naked eye during the four years 1893-96. There were only twenty-four such occasions during that period, and these occurred almost entirely with a North-westerly wind. He (Mr. Marriott) had referred to the *Daily Weather Charts* for those dates, and found that they nearly all occurred in the South-west quadrant or rear of a passing depression, and were in most cases followed by rain. In the paper on "Popular Weather Prognostics," which Mr. Abercromby and he (Mr. Marriott) read before the Society in 1882, a chart was given showing that visibility occurred with wedge-shaped isobars. A very good illustration of these conditions occurred on August 28, 1892, when he (Mr. Marriott) was at Bude. The air was remarkably clear, hills at a distance of 50 miles being distinctly seen. The conditions under which visibility occurred seemed also to be favourable for audibility. In 1894 he (Mr. Marriott) read a paper before the Society on the Audibility of "Big Ben" at West Norwood,[1] in which he showed that the bell was most frequently heard with winds from West to North.

Mr. W. **Ellis** said that he wished only to speak to a question of fact, as bearing on Mr. Russell's statement that visibility sometimes increases to a remarkable degree before rain. At Greenwich there is a very extensive view from the Observatory hill over the river towards the Isle of Dogs and Blackwall. Very generally the prospect in this direction is obscured by more or less haze, but on rare occasions the outlines of the distant buildings are seen with remarkable distinctness, at which times, no matter how fine the weather at the moment may apparently be, rain has almost universally been found to follow within a very few hours, usually before the next morning. This has been noticed on occasions for very many past years.

Mr. F. A. R. **Russell** said in reply that he had had great difficulty in compressing his conclusions within the limits which are convenient, and was obliged in the end to exclude the figures giving the actual results of his observations, for they could not be dealt with concurrently. With regard to what Mr. Gaster had said of the obscurity of his remarks on the effect of a West or North-west taking the place of a South-west wind, he wished to point out that the effect of a sudden change was a temporary loss of transparency, followed by a clear air, while the effect of a gradual veering was a continuous increase of transparency. Mr. Marriott's observations on audibility quite agreed with his own on visibility in relation to direction of wind, and seemed to point to a similar cause for both, at least in many cases. He had not found, as Mr. Ellis and others had, that transparency was most frequently followed by rain, but a situation near a town would probably prevent any great transparency in settled weather.

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[1] *Quarterly Journal*, vol. xx. p. 243.

AN ATTEMPT TO DETERMINE THE VELOCITY EQUIVALENTS OF WIND-FORCES ESTIMATED BY BEAUFORT'S SCALE.

SUBMITTED TO THE WIND-FORCE COMMITTEE.

BY RICHARD H. CURTIS, F.R.Met.Soc.

[Read December 16, 1896.]

Speaking very generally, there are two ways in which the force of the wind is observed by meteorologists: (1) instrumentally, by means of some form of anemometer; and (2) by estimation, for which purpose the extreme range of wind-force is arbitrarily divided into a given number of parts, constituting a scale, of which only a mental conception can be formed by the observer.

Of these two methods, the second is adopted far more generally than the first.

When employed by a practised observer, the method of estimation possesses one great advantage over the use of an anemometer in the fact that the observer is not confined to a particular point of space, as the instrument must (in its usual form) necessarily be; nor is the observer restricted to recording the force as registered in a given interval of time. On the contrary, he can base his estimate on the observed effects of the wind on objects both near and distant; and, by taking note of the variations of the force from moment to moment, he is often able to form a better idea of the general strength of the wind-current in his neighbourhood than could be obtained from the records of an anemometer.

On the other hand, the method has its disadvantages, the gravest of which is that there is no absolute standard to which the mentally-conceived scales can be referred. Every observer has to form his own idea of the scale, basing it upon certain broad and general lines, which are all that can be laid down for his guidance. But in doing this he must of necessity draw largely upon his own experience; and here both the mental temperament of the observer, and the physical features of the locality in which he lives, are factors which can hardly fail to influence the result at which he arrives.

Another disadvantage, which, however, refers less to the principle than to the practice of the method, is to be found in the diversity of scales in use amongst meteorologists of different countries. The range of wind-force is indicated, in different scales, by from 5 to 13 numbers, and this renders it very difficult, if not impossible, to make any reliable comparison between them.

In England, the scale in general use is that devised in 1805 by Admiral Beaufort, and still known by his name. It consists of 13 numbers, or points, ranging from "0," indicating a calm, to "12" which denotes a hurricane. This scale is distinguished from others in being based upon a definite standard, namely, the sail-carrying power, and to some extent the speed, of a ship of a specified build and rig. For seamen used to large sailing ships, this, modified to suit the exigencies of modern build and rig, is doubtless a very convenient standard to adopt; but apart from the question whether it is of equal value to other seamen who have not had such experience, it is certain that to landsmen, who form after all the great majority of our observers, the sail equivalents are quite unintelligible, and therefore useless. If, therefore, it is desired to secure uniformity of practice—if, in other words, a given figure of the scale is to indicate the same force of wind, wherever it is used, on land or at sea, it becomes necessary to adopt some other and more generally available standard, one which can be appealed to by landsmen and seamen alike.

Such a standard, capable of meeting all the requirements a standard should possess, it is difficult to find; but perhaps the nearest approach to it would be the anemometrical equivalents corresponding to each point of the scale; and, since velocity anemometers are not only more reliable, but are also far more generally employed than pressure anemometers, there can be little doubt but that the equivalents should be in terms of velocity rather than of pressure. It is obvious that the proper method of determining these equivalents would be to make a direct comparison between the estimated wind-forces at a given station, and the indications of a velocity anemometer at the same place. As a matter of fact, equivalent velocities, and sometimes pressures, have been given for most of the scales now in use. A glance at these equivalents will, however, show that they differ widely amongst themselves; and this is indeed only what might have been looked for, when it is remembered that in the majority of cases they are based on nothing firmer than purely theoretical assumptions, unsupported by experiment of any kind; and that when this was not the case, the experiments employed for the purpose were not only very limited in number and in their scope, but were also, in some instances at least, open to grave objection as to their character, and the way in which they were carried out.

As far as I have been able to ascertain, there have hitherto been but three serious attempts made to determine, by means of a direct comparison, the relation between estimated wind-forces and the velocity of the wind as measured by an anemometer; and in each of these cases it was sought to find the equivalents for Beaufort's scale. The first of these comparisons was made in 1874 by Mr. R. H. Scott, F.R.S., with the assistance of Mr. F. Gaster (*Quarterly Journal Royal Met. Society*, vol. ii. p. 109); the second in 1879 by Dr. A. Sprung (*Aus dem Archiv der Deutschen Seewarte*, II Jahrgang 1879, No. 2, p. 19); and the third in 1887 by Mr. G. Chatterton, M.Inst.C.E. (*Quarterly Journal Royal Met. Society*, vol. xiii. p. 216).

For such a comparison to be entirely satisfactory, four conditions are essential:

(1) The observations should be made at an exposed station, where it may reasonably be expected that the full range of wind-force would be experienced.

(2) The station should be provided with an anemometer, the constants of which are known, and which should occupy a position in which it is entirely free from purely local disturbing influences.

(3) The estimations of wind-force should be made by an observer of experience, stationed in the same locality as the anemometer, but acting independently of its indications.

(4) There must be available a sufficiently long series of observations to yield reliable mean results.

The third and fourth of these conditions will probably be considered sufficiently axiomatic to be at once accepted; but I may be allowed to make a few remarks in support of the first and second.

The first appears to me to be indispensable, because, as I have already suggested, the conception of the scale which an observer will form for himself must necessarily be influenced by his experience, which in its turn will depend very much upon the locality in which he lives, and the character of his surroundings. It is a fact, which our anemometer records place beyond question, that at inland stations the high velocities, which are frequently experienced in gales on our western coasts, are never reached; and also that, whilst those highest rates are rarely attained on our eastern coasts, they are felt there only with easterly gales, and never with gales from the westward, which have to traverse a considerable extent of land before they reach that region. Yet a comparison which I have made of the relative frequency with which the different forces were reported, during a period of three years, from two stations, one on the coast and the other well inland, but at the same time sufficiently near to each other to be similarly affected by the distribution of pressure, shows that this fact is not confirmed by the estimated forces.

The stations I selected were Yarmouth and Cambridge, about 70 miles distant from each other, and the comparison elicited the important fact, that at Cambridge the highest forces were reported with greater frequency than they were at the more exposed coast station. This will be seen from the figures in Table I.

TABLE I.—NUMBER OF TIMES EACH FORCE WAS REPORTED FROM CAMBRIDGE AND YARMOUTH DURING THE THREE YEARS 1893 TO 1895.

Number of times reported from	Force by Beaufort's Scale.										
	0	1	2	3	4	5	6	7	8	9	10*
Cambridge .	50	998	393	325	185	122	60	29	19	5	2
Yarmouth .	40	156	496	648	474	222	96	36	16	4	0

* No force above 10 was reported during the three years.

The truth seems to be that observers everywhere adopt, as the upper limit of their scale, the strongest wind they have personally experienced, and conceive the lower gradations of force in accordance therewith. Yet I think there can be no doubt that a wind blowing at a given velocity would be estimated by an observer, at an inland station, at a much higher figure than would be given for it by another, whose experience had been gained, say, on an exposed part of our western coast, or in the Shetlands, or at sea. From this I think it follows that if we are to get true estimations of, and equivalents for, the highest wind-forces, and also a properly graduated scale, we must use for the purpose observations made at stations where those forces are really experienced, and where we may therefore expect that the intermediate forces bear a proper relation to the extremes of the scale.

The second condition is not less important than the first, and is necessary to ensure that the instrumental data employed in the comparison shall be of a reliable character. As regards the first part of it there is now no difficulty, since it has been shown conclusively that by using 2·2 instead of 3·0, as the factor for the large, or "Standard" size Robinson anemometer, we obtain results very nearly if not absolutely correct; and the means are available for determining with equal accuracy the factors proper to cup anemometers of other dimensions also.[1]

The second part of the condition is, however, less easy to satisfy, and unfortunately it renders useless for the purpose of this paper some series of observations which otherwise one would have been glad to use. In support of this statement, and as an example of the effect which the surroundings of an anemometer may produce upon its records, I may be permitted to refer to a paper I submitted to the Society last session, on the exposure of the Robinson cup anemometer at Holyhead,[2] in which it was shown that the effect of the "purely local disturbing influences" was to cause that instrument to record 22 per cent too much when the wind blew from one point, and 28 per cent too little when it blew from another, with errors of smaller and varying magnitude at nearly every intermediate point of the compass. No doubt this case is in some respects exceptional, but there are good grounds for believing that the records of many other anemometers are, to a greater or less extent, affected in a somewhat similar manner; and if, as I have already said, an anemometer, as compared with an observer, is placed at a disadvantage in being confined to a particular spot, it becomes the more important to secure for it a position in which it shall enjoy a perfectly free and unobstructed exposure to the wind.

The whole of these four conditions do not appear to have been fully met in either of the three attempts previously made to determine the wind-velocity equivalents for Beaufort's scale.

Mr. Scott's values, which he himself said were only "provisionally adopted," were mainly based upon four months' observations made at Holyhead in 1869-70, supported by observations at Yarmouth covering a further period of three months. At the date of making these comparisons the accuracy of Dr. Robinson's original factor 3, for all anemometers, was almost unquestioned, and certainly the correct factor for the standard size instrument was not known. Neither was there the least suspicion that the surroundings of the Holyhead instrument affected its indications in the way they are now known to do. Further, the number of observations used for the comparison was small, the total for Holyhead being only 433; and for Yarmouth 605, which latter number was, however, largely reduced by the rejection of all observations from Westerly points. Without going more into detail, it seems clear that in this case neither the second, nor the fourth, of my conditions was fulfilled. Mr. Scott made a further comparison between the anemometer records at Falmouth and the observed wind-forces at the Eddystone, and the contradictory character of the results he obtained led him to the general conclusion that "the conditions of exposure of the anemographs exert an overwhelming influence on their action"; and also to call "the attention of meteorologists to the extreme caution which must be used in drawing conclusions from anemometrical data."

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[1] On this point see also p. 43.

[2] *Quarterly Journal Royal Met. Society*, vol. xxii. p. 237.

Dr. Sprung's comparison was made with the anemometer results from four stations in Northern Germany, for the years 1876-78, and it comprised a total of 3594 observations. It had therefore a great advantage over Mr. Scott's comparison as regards the number of observations used, but it would appear to have been at a disadvantage as regards the position of the stations. I have no information as to the local exposure of the instruments, which was probably good; but however this may have been, I should not expect to find the full range of wind-force in the region they occupied, because I believe that the strong winds which are not infrequent on our own western coasts are seldom, or never, experienced there. This conjecture appears to be supported by the very low velocity equivalents obtained by Dr. Sprung, especially for the higher forces, and by the further fact that apparently nothing exceeding a "fresh gale" was experienced during the period. Dr. Sprung corrected his anemometer results for error in the factor of the instruments, adopting 2·4 as the correct value.

In Mr. Chatterton's attempt the anemometer values of three stations, Holyhead, Falmouth, and Yarmouth, for the year 1881, were used. The Holyhead values he compared with estimated forces observed at the South Stack lighthouse, and on the Carnarvon Bay lightship. The Falmouth values were compared with forces observed at the Eddystone and at the Wolf lighthouses. The Yarmouth values were compared with estimated forces recorded at six lightships, moored at various distances off the Norfolk coast. The results of the various comparisons differed considerably amongst themselves, and Mr. Chatterton concluded that those derived from the comparison between Holyhead and the Carnarvon Bay lightship were "probably most reliable of all." But in arriving at this conclusion he assumed, as Mr. Scott had done before him, that the anemometer at Holyhead could be relied upon, which we now know was not the case. The Falmouth anemometer was certainly not well placed for comparison with isolated rock lighthouses, both far out at sea, the one 50 miles to the eastward and the other as far to the westward. Yarmouth yielded very contradictory results, probably owing in part to the distances which separated some of the lightships from the anemometer, and in part to want of care in making the observations on some of the vessels. Without going more into detail, it appears that here also the second and third, and possibly the fourth, of the conditions were not sufficiently fulfilled.

For the purpose of the present attempt to find the relation between the velocity of the wind and the force by Beaufort's scale, the Meteorological Council very kindly placed at my disposal the records from all their anemometer stations in the British Isles. These number in all 14; but after carefully considering each it appeared to me that only one, Scilly, met fully all the conditions I have named; and I therefore adopted that station as the principal one for the purpose of the comparison. Of the other stations, some did not meet the first condition, and others failed to satisfy the second, or third. At two stations, Orkney and Fleetwood, the anemometers are exceptionally well placed, in localities which experience the strongest winds felt in these islands, but unfortunately there were no estimated forces made close at hand available for the comparison. Fleetwood, however, I have used, as a check upon the results obtained from Scilly, employing for the comparison the estimated forces recorded on the Morecambe Bay lightship; but for Orkney I could get no observations at all within reasonable distance. As a further check, I have used the Yarmouth values for certain winds; and also the records of the Holyhead pressure-tube anemometer, which is free from the faults that attach to the Robinson instrument near at hand.

TABLE II.—COMPARISON BETWEEN THE ESTIMATES OF WIND-FORCE MADE BY THE METEOROLOGICAL OFFICE OBSERVER AT ST. MARY'S, AND THE LIGHTHOUSE-KEEPERS AT ST. AGNES, ISLES OF SCILLY, DURING THE YEARS 1894 AND 1895.

	Estimated Force by Met. Office Observer. Beaufort's Scale.									
	0	1	2	3	4	5	6	7	8	9
A.M.*										
Estimated Force by Lt.-Keeper	0·0	1·8	2·7	3·2	4·3	5·4	6·5	7·2	8·3	9·0
Number of Observations .	1	59	40	98	199	173	97	45	12	7
P.M.†										
Estimated Force by Lt.-Keeper	0·5	1·5	2·5	3·1	4·3	5·5	6·5	7·5	8·5	9·5
Number of Observations .	4	36	44	116	213	170	83	49	12	4
A.M. and P.M. combined.										
Estimated Force by Lt.-Keeper	0·4	1·7	2·6	3·2	4·3	5·5	6·5	7·4	8·4	9·2

* Meteorological Office Observations made at 8 a.m., Lighthouse at 9 a.m.

† Both Observations made at 6 p.m.

An important point, which it was desirable to test at the outset, was the accuracy with which the force of the wind was estimated by the Meteorological Office observer at Scilly. For this purpose I obtained the loan of the logs kept for two years at the St. Agnes lighthouse, which is one and a half miles south of the anemometer on St. Mary's, and has an exactly similar exposure, and compared the estimates made at the two places. The results are given in Table II., and are, I think, very satisfactory. As a rule the lightkeepers estimated the force slightly higher than the Meteorological Office observer; but, if we except forces 1 and 2, the mean difference never exceeds half a point, and is generally less. It must, however, be remembered when weighing these figures, that not only is the Meteorological Office observer a seaman, who has had several years' experience in making these observations, but he has necessarily to make them in the open air, at the times specified; and these are conditions which do not apply so strictly to lighthouse-keepers, who in the daytime are often busy in cleaning their apparatus, or on other duties. I should therefore, in this case, give decidedly greater weight to the observations of the Meteorological Office observer than to those of the lighthouse-keepers.

The Robinson anemometer in use at Scilly is of smaller dimensions than the "Standard" or "Kew" pattern, the cups being but 5 inches in diameter, and the arms 12 inches long. The constants for this type of anemometer not having been previously determined, it was necessary to determine it, before the records could be used. This I did through the medium of a pressure-tube anemometer, and the results of the determination will be published in the *Report of the Meteorological Council* for the year ending March 1896. It will suffice to say here, that the factor is not uniform throughout the scale; for velocities not exceeding 25 miles per hour it is very nearly 3, but for higher velocities it is slightly less; and in the present work the records have been dealt with accordingly.

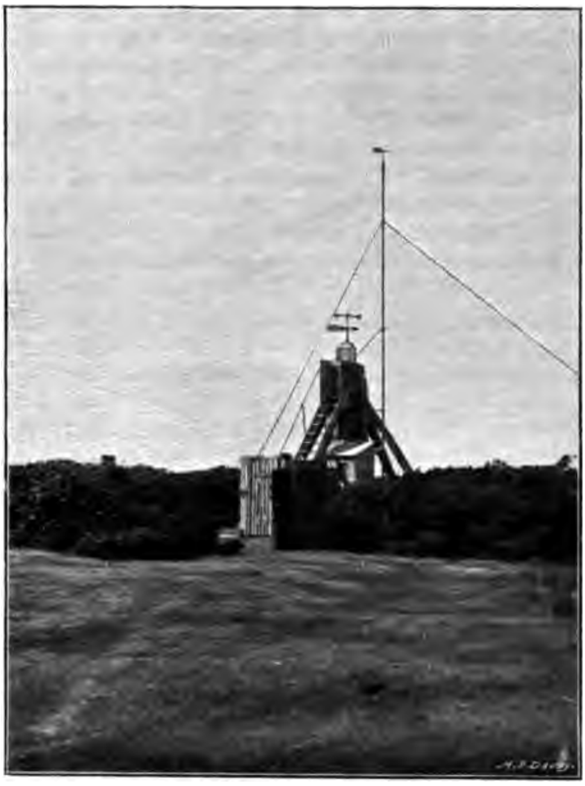

FIG. 1.—Robinson and Pressure-Tube Anemometers at St. Mary's, Isles of Scilly.

The exposure of the instrument is extremely good. It stands upon the western portion of the island of St. Mary's, upon a stone pillar 20 feet above the ground, which is level in the immediate neighbourhood; and it has a perfectly free horizon in all directions. The situation of the islands, also, at the mouth of the English Channel, 30 miles west of the Land's End and right in the track of some of our deepest depressions, makes it extremely probable that the full range of wind-force is felt there; and at the same time the experience of the observers, and the close agreement between the independently-made observations shown in Table II., leave little doubt that the wind-scale is properly appreciated.

TABLE III.—MEAN VELOCITY EQUIVALENTS OBTAINED FROM THE OBSERVATIONS MADE WITH THE ROBINSON ANEMOMETER AT SCILLY.

		Estimated Force by Beaufort's Scale.												
		0	1	2	3	4	5	6	7	8	9	10	11	12
Equivalent Mean Velocities (corrected) for each of the Eight directions (miles per hour).	N No. of Obs.	Calms were very infrequent.	3·7 52	5·9 58	8·6 117	12·2 250	18·9 204	24·9 93	30·3 51	34·7 31	41·5 13	52·3 3	... ...	No observation of force 12 was recorded.
	NE No. of Obs.		3·5 45	6·4 81	8·8 116	12·3 257	18·1 191	23·3 91	29·6 41	35·4 14	38·3 3	... ...	... ...	
	E No. of Obs.		3·7 69	6·9 93	9·8 146	13·9 311	20·5 245	25·8 151	32·1 80	37·4 44	43·8 18	50·2 5	... ...	
	SE No. of Obs.		3·9 46	7·2 74	8·8 114	13·9 186	20·3 140	26·4 101	33·0 57	39·5 28	43·6 17	50·4 5	... ...	
	S No. of Obs.		3·8 54	6·5 60	9·6 125	13·4 282	19·3 207	25·4 148	30·8 87	36·1 53	41·8 17	53·5 2	63·0 1	
	SW No. of Obs.		4·2 58	6·8 92	9·4 166	13·8 373	19·5 271	25·7 161	30·7 121	35·1 44	43·8 11	... ...	60·5 2	
	W No. of Obs.		4·2 90	6·7 114	9·7 175	14·5 352	20·8 307	28·3 163	33·2 143	37·4 117	42·6 32	51·6 18	60·4 5	
	NW No. of Obs.		4·0 69	6·6 74	9·2 144	13·5 380	20·1 310	26·9 164	31·8 111	37·4 84	43·7 35	51·6 12	65·7 7	
Mean of all directions (uncorrected) No. of Obs.		... ...	4·0 491	6·8 730	9·4 1237	13·7 2766	19·9 2162	26·1 1261	31·5 831	35·6 535	41·5 185	51·7 51	63·1 15	... ...
Mean of all directions (corrected) No. of Obs.		... ...	3·9 483	6·7 646	9·3 1103	13·5 2391	19·8 1875	26·0 1072	31·7 691	36·9 415	43·0 146	51·5 45	63·1 15	... ...

Total number of observations, 10,263.

For the comparison I used all observations of force 7 and upwards recorded during the last 15½ years. For force 6 I did not need to go back further than 10½ years, and for forces below 6 only to 9½ years, to get enough observations to yield reliable means. In all 10,263 observations were dealt with. These were first grouped for each force under eight points of the compass, and the mean equivalent velocity was obtained for each group. It is to be remembered that the observations represent the number of miles registered by the anemometer from thirty minutes before to thirty minutes after the moment of estimating the force; and in ordinary winds this mileage will indicate very fairly the mean velocity (rate) at any moment during the hour. But occasionally the occurrence of a marked increase or decrease of force during the period causes this to be no longer the case, and the velocity registered will differ considerably from that generally obtained with the force observed. I therefore, at this stage, went carefully through all the observations, and excluded all extreme velocities which showed a difference, either plus or minus, exceeding certain limits from the mean already obtained, and thus got a corrected mean equivalent velocity. Generally speaking, the two means agreed closely, especially when the winds from all points of the compass were combined; the differences are largest with the higher forces, which are usually more gusty and variable than lighter winds; and the corrected means are no doubt the more reliable of the two.

In Table III. will be found these corrected means for each force, and for each of the eight points of the compass, and also both the corrected and uncorrected means for all the directions combined. The grouping under direction shows rather lower equivalent velocities for North and North-east winds, and rather higher for West winds, than for the other points; but there is absolutely nothing in the exposure of the instrument to account for this, which I believe is due rather to the fact that the generally harsh "quality" of the North-east winds leads to a slight exaggeration of their force, whilst the milder West wind produces upon the observer just the opposite effect. The differences from the general means are, however, never large.

The (corrected) means of all directions combined show a fairly uniform progression, the differences between the successive points of the scale increasing, as a rule, with increase of force.

TABLE IV.—Comparison of the Equivalent Velocities found by Mr. Scott, with those yielded by the Anemometer at Scilly.

		Force by Beaufort's Scale.												
		0	1	2	3	4	5	6	7	8	9	10	11	12
Mr. Scott's Values (miles per hour)	Fact. 3	3	8	13	18	23	28	34	40	48	56	65	75	90
	,, 2·2	2	6	10	13	17	21	25	29	35	41	48	55	66
Scilly Values (corrected)		...	4	7	9	14	20	26	32	37	43	52	63	...
Difference Sy.—S.		...	−2	−3	−4	−3	−1	+1	+3	+2	+2	+4	+8	...
Percentage of differ. to Scilly Values		...	°/₀ 50	°/₀ 43	°/₀ 44	°/₀ 21	°/₀ 5	°/₀ 4	°/₀ 9	°/₀ 5	°/₀ 5	°/₀ 8	°/₀ 13	...

The values differ, of course, from those found by Mr. Scott, because his were based on the erroneous factor 3; but after correcting them to factor 2·2 they still differ considerably, all Mr. Scott's equivalents for forces 5 and below being higher than mine, whilst those for forces 6 and above are lower. The differences vary from 4 per cent with force 6 to 50 per cent with force 1. It is curious that a similar difference is now shown when the Scilly values are compared with those obtained from the Holyhead pressure-tube instrument, although the Holyhead instrument and its exposure, and also the observer, are not the same as were employed by Mr. Scott; later on I shall refer to this point again. In Table IV. Mr. Scott's values are compared with my own.

Having proceeded thus far, I now sought to compare the results obtained with those yielded by other places, in order to see to what extent they would be supported or otherwise by such a comparison. I have already said that since the autumn of 1895 a pressure-tube anemometer has been in operation at Scilly, and I therefore first turned to it for a check upon the instrumental side of the work, of much the same kind as that which I had already applied to the estimations of the observer.

From the records of this instrument a good mean velocity can be obtained for a much shorter interval of time than is possible with the Robinson records; and therefore two measurements were taken for each observation of force—one for ten minutes, from five minutes before till five minutes after the moment of observation, and the other for an hour, as with the Robinson record. The means of both sets are given in Table V., and they agree very closely with each other, as they do also in the similar case of Holyhead. This is most important, because it shows that the mean velocity for the hour is also in the great majority of cases the mean for any part of the hour; and that the hourly means which have been used in carrying out this work may safely be accepted for comparison with estimates of force which cover but a few minutes of time. With each observation the absolute maximum and minimum force recorded during the ten minutes was also extracted, and the means of these give some idea of the average range of wind-velocity which may be expected with each force of Beaufort's scale. The results are given in Table V. With most of the forces the equivalent velocities obtained from the pressure-tube agree very closely indeed with those obtained from the cup instrument (Table III.), especially when the difference in the number of observations is borne in mind.

TABLE V.—MEAN EQUIVALENT VELOCITIES OBTAINED FROM PRESSURE-TUBE ANEMOMETER AT SCILLY.

Mean Vel. in miles per hour from	Force by Beaufort's Scale.											
	0	1	2	3	4	5	6	7	8	9	10	11
Hourly Values	...	2·9	5·9	8·9	13·8	19·2	24·8	30·9	39·5	44·7	52·0	64·0
10 Min. Values	...	2·9	6·0	9·0	13·9	19·2	24·7	30·8	38·6	44·6	55·0	67·0
Mx. in 10 Mins.	...	3·8	7·8	11·6	17·6	24·4	31·6	39·7	51·4	57·8	70·0	81·0
Mn. in 10 Mins.	...	2·0	4·0	6·2	9·6	13·3	17·2	21·2	28·5	30·7	35·0	48·0
Range . .	...	1·8	3·8	5·4	8·0	11·1	14·4	18·5	22·9	27·1	35·0	33·0
No. of Observns.	...	88	76	187	306	239	116	58	20	9	1	1

Total number of observations, 1101.

I now turned to the Fleetwood anemometer, which I have already mentioned as occupying a good position with an uninterrupted exposure. I had hoped to get estimated forces from the logs of the lighthouses near at hand, but these are not under the control of the Trinity House, and unfortunately the keepers do not use Beaufort's scale in their weather records. The nearest observations available were those made on the Morecambe Bay light-vessel, moored 20 statute miles due west of the anemometer, and I obtained from the Trinity House eight years' logs, which were very kindly lent for the purpose. Notwithstanding their distance apart, I have little doubt that the mean force at the two stations is generally the same, and more particularly so when the winds are strong. Observations are recorded on board the ship every three hours, but except in gales only a limited number per day was extracted from the log; in heavy weather every observation was used.

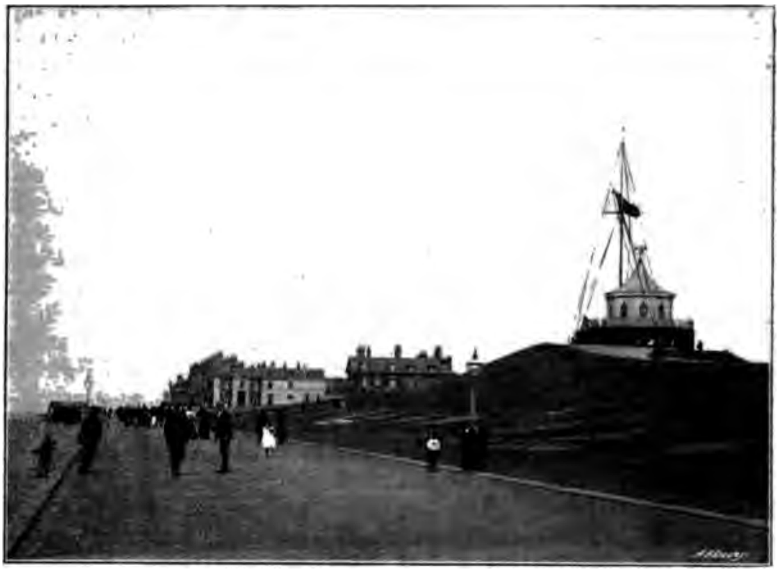

FIG. 2.—Robinson Anemometer at Fleetwood.

TABLE VI.—MEAN EQUIVALENT VELOCITIES OBTAINED BY COMPARING THE ROBINSON ANEMOMETER VALUES AT FLEETWOOD WITH THE ESTIMATED FORCES OBSERVED ON BOARD THE MORECAMBE BAY LIGHT-VESSEL.

		Force by Beaufort's Scale.												
		0	1	2	3	4	5	6	7	8	9	10	11	12
Mean Vel. at Fleetwd. (miles per hour)	Uncord.	...	5·1	8·1	11·6	15·9	20·7	26·2	31·5	37·5	46·3	51·8	57·7	74·1
	Corrd.	...	4·6	8·0	11·3	15·8	20·7	26·2	31·8	37·9	44·1	52·7	59·9	74·1
Scilly . . .		...	3·9	6·7	9·3	13·5	19·8	26·0	31·7	36·9	43·0	51·5	63·1	...
Number of Obs. (Fleetwood)		...	195	397	736	800	591	433	631	275	95	29	10	4

Total number of observations, 4196.

The method of dealing with the observations was the same as that followed in the case of Scilly; but as the anemometer is of the standard type it was first necessary to reduce the velocities obtained from it to factor 2·2, instead of 3. In Table VI. the corrected, and uncorrected, means obtained from all directions combined, are given, together with the corrected mean from the Scilly observations for comparison. The equivalents for most of the forces are higher than Scilly, and for some of the lower forces the difference between the two is relatively large. It is just there, however, that the distance between the two stations would be most likely to affect the result; with forces 5 and upwards the difference becomes small, and with 6 and 7 it disappears. Generally, I think the results give strong support to the values obtained from the Scilly observations, and the support is all the stronger in that it comes from an instrument of a different size from that in use at Scilly.

The next station employed was Yarmouth, which I used partly because it had been already used by both Mr. Scott and Mr. Chatterton, and partly because the records cover a long period of time. I followed my predecessors' lead in using only winds which reached the anemometer from off the sea, but I did not employ, as they did, estimated forces observed on board the lightships, because there exists a long series of observations made by the Meteorological Office observer, under the same general conditions as those which govern the anemometer, and which I thought it the fairer course to employ. A comparison was, however, made between the estimations of wind-force at the St. Nicholas Gat lightship, moored about two miles to the south-east of the anemometer, and the corresponding observations made by the Meteorological Office observer on shore. In this case the observations were grouped under the four cardinal points, and the results are shown in Table VII.

TABLE VII.—COMPARISON BETWEEN THE ESTIMATES OF WIND-FORCE MADE BY THE METEOROLOGICAL OFFICE OBSERVER AT YARMOUTH, AND ON THE ST. NICHOLAS GAT LIGHTSHIP, DURING THE YEARS 1894 AND 1895.

		Force estimated by Meteorological Office Observer. Beaufort's Scale.									
		0	1	2	3	4	5	6	7	8	9
Corresponding Forces as estimated by Lightshipmen, with winds from:	North	...	1·1	2·1	3·0	3·8	5·1	5·7	6·7	...	...
	Number of Obsns.	...	31	74	105	65	32	13	3	...	...
	West	...	1·4	2·2	3·2	4·2	5·1	6·3	7·2	8·0	...
	Number of Obsns.	...	38	135	153	92	37	20	5	2	...
	South	...	1·5	2·2	3·1	3·7	4·8	5·6	6·9	...	...
	Number of Obsns.	...	20	88	112	87	23	12	6	...	...
	East	...	1·3	1·5	2·2	3·1	4·0	4·9	5·9	6·4	7·7
	Number of Obsns.	...	12	64	59	63	51	21	11	7	3
	Mean of all directions combined.	0·8	1·3	2·1	3·0	3·8	4·6	5·6	6·5	6·8	7·7
	Mean N. and S. only.	...	1·2	2·2	3·0	3·7	5·0	5·6	6·8	...	...

From the figures given here it will be seen that with Westerly winds the lightshipmen estimate the force slightly higher than does the observer on shore; but that with Easterly winds the lightship estimations are about one point lower; with North and South winds the lightship figures are generally a little less than those given by the shore observer.

The explanation of this I believe to be as follows:—Assuming the lightshipmen to gauge the force correctly, the Meteorological Office observer over-estimates *all* his forces, from whatever direction the wind may blow. When the wind is Easterly it blows both upon the lightship and the shore without obstruction, and with equal force, and the difference in the two estimations at once becomes apparent. But from Westerly winds the shore observer is more or less sheltered, and their force, as *actually felt by him*, is less than is experienced on the lightship in the offing. This difference in the force is, however, just about balanced by the error in the shore observer's estimate, and therefore it happens that the forces recorded at the two places nearly agree. The North and South groups include winds from North-east to North-west, and South-east to South-west, respectively, and as the sheltering only occurs with winds blowing from the West of North, or of South, one might expect to find the results, under these two groups, somewhat modified by the inclusion of the Easterly winds, which is what really occurs.

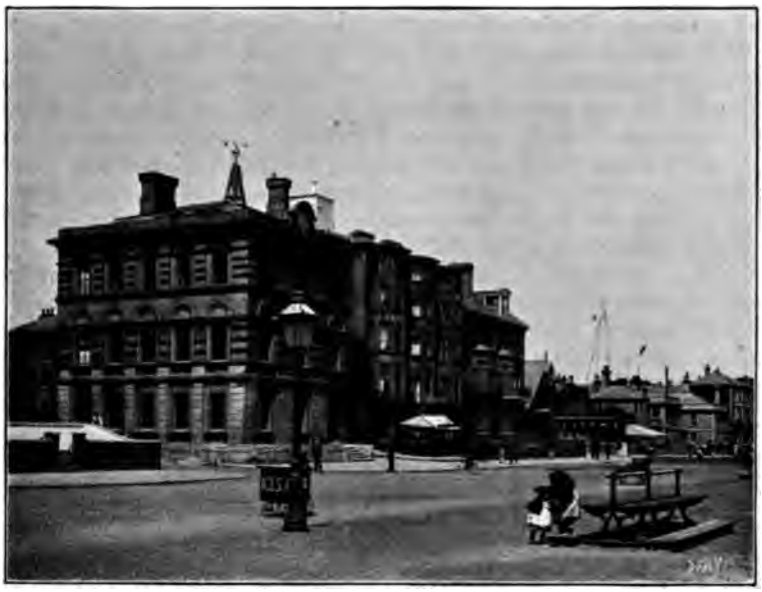

FIG. 3.—Sailors' Home and Robinson Anemometer, Yarmouth.

The position of the anemometer, however, is not entirely satisfactory. The Sailors' Home, on which it stands, is a building about 50 feet high, and the cups are only 14 feet above the parapet, and 10 feet above the ridge of the roof. At the north-east corner of the roof are a chimney stack, and a small wooden structure in which a light for vessels is exhibited at night; the top of the stack is 6 feet below the cups, and only 4 feet from the stand which carries them. To the east the building fronts the sea; to the north are a couple of buildings, close at hand, and as large as the Sailors' Home; whilst to the south are other buildings, but much lower and further removed. From north, through west, to south extends the town of Yarmouth, level and with few buildings as high as the Sailors' Home.

The method of dealing with the observations was the same as that followed at the other stations, and the instrument being of the standard type, they were also reduced to factor 2·2. The results are shown in Table VIII.

TABLE VIII.—EQUIVALENT VELOCITIES OBTAINED FROM THE ROBINSON ANEMOMETER AT YARMOUTH.

		Estimated Force by Beaufort's Scale, by the Meteorological Office Observer.										
		0	1	2	3	4	5	6	7	8	9	10
Mean Velocity (corrected) in miles per hour, with winds from	N	...	4·0	7·6	9·5	13·7	18·3	23·6	29·9	30·8	...	No observations of forces above 9.
	NE	...	3·9	6·6	10·3	15·1	20·5	25·6	31·9	34·6	41·3	
	E	...	4·5	7·0	10·5	15·6	21·1	25·8	31·3	37·0	44·6	
	SE	...	4·4	7·0	10·3	14·9	19·9	25·2	30·4	35·4	46·2	
All Directions (corrected)		...	4·2	7·0	10·2	14·9	20·3	25·4	31·2	35·8	43·9	
Do. (uncorrected)		...	4·2	6·8	10·1	14·8	20·2	25·4	31·2	35·9	45·0	
No. of Observations		...	438	1082	1439	1457	714	455	170	85	17	

Total number of observations, 5857.

The anemometer is undoubtedly affected by its position on the roof of a large building, and the result is seen directly the wind-force rises to a moderate breeze.

With North winds the velocity is lower than with winds of the same force blowing from either of the other three points; with South-east winds it is higher than with North winds, but still lower than with East or North-east winds, the East winds being generally the stronger of the two last named. The North winds are no doubt obstructed by the high adjoining houses; but most probably all the winds included in the table are thrown up above the building in such a way as to increase the velocity at the cups. The South-east exposure is probably the best, as the wind would strike the building at its corner, and would be to some extent deflected past the front and side of the house, instead of being all thrown above it.

Now, assuming the lightship estimations of force to be correct, these velocity equivalents should all be shifted one column to the left, since they correspond, speaking generally, to about one point of Beaufort's scale less than that under which they are placed in the table. If this is done they will all appear too high, as compared with those obtained from the Scilly and Fleetwood observations; and I suggest that the difference represents the effect on the cups due to the building.

With Westerly winds, however, the throwing up of the air would occur, in all probability, chiefly on the other side of the town; so that one may regard the general level of the house-tops as corresponding to the ground level in the case of an instrument exposed in an ordinarily open situation. The small height of the cups above the roof—ten feet—will now cause them to suffer from the retardation of the air due to its passage across the town, and they will in fact be sheltered in the same way as the observer: if we further assume that the *amount* of the "sheltering" is the same in the two cases, and that there is no further effect produced upon the cups, by the building, then the velocity equivalents obtained for Westerly winds, when compared with forces one point lower than those given by the observer, to allow for his error of observation, should agree with the equivalents obtained at the other stations.

To test this hypothesis I extracted the velocity equivalents for Westerly winds (NW—SW) from three years' observations, and the results largely support the supposition:—

TABLE IX.—VELOCITY EQUIVALENTS FOR WESTERLY WINDS, AT YARMOUTH, FROM THREE YEARS' OBSERVATIONS.

	Force estimated by Meteorological Office Observer—Beaufort Scale.								
	1	2	3	4	5	6	7	8	9
Mean Velocity—Yarmouth	...	6·1	8·8	12·5	15·7	20·5	27·0	32·3	...
,, ,, —Fleetwood	...	4·6	8·0	11·3	15·8	20·7	26·2	31·8	...
,, ,, —Scilly (miles per hour)	...	3·9	6·7	9·3	13·5	19·8	26·0	31·7	...
	...	1	2	3	4	5	6	7	8
	Estimated Force for Fleetwood and Scilly values, and (approximately) corrected force for Yarmouth.								

From this it will be seen that if the estimated forces are lowered by one point the equivalent velocities will then agree very closely, except for the lightest winds, with those obtained from the Fleetwood observations, although the agreement with the Scilly values is not quite so good.

TABLE X.—MEAN EQUIVALENT VELOCITIES OBTAINED FROM THE PRESSURE-TUBE ANEMOMETER AT HOLYHEAD.

		Force by Beaufort's Scale.									
		0	1	2	3	4	5	6	7	8	9
Mean Velocity (miles per hour)	Hourly Values	2·5	5·1	8·6	12·7	17·1	21·2	24·0	27·6	34·0	38·5
	Ten Min. Values	2·2	4·9	8·6	13·0	17·2	21·4	24·4	27·8	33·8	39·1
	Max. Ten Mins.	...	6·0	10·5	15·7	21·3	26·7	30·2	35·9	43·1	51·0
	Min. Ten Mins.	...	3·7	6·5	9·9	12·9	15·9	17·8	19·7	24·2	27·5
Range		...	2·3	4·0	5·8	8·4	10·8	12·4	16·2	18·9	23·5
No. of Observations		46	96	133	209	152	101	91	59	42	15

Total number of observations, 944.

Of course it is possible that the Meteorological Office observer's estimations of wind-force are nearer the truth than those made on board the lightship; but in that case it is not at all easy to account for the persistent difference between the two values shown with Easterly winds, and for the agreement in the case of Westerly winds. We have here, however, another illustration of the uselessness of erecting anemometers upon bulky buildings; their indications are sure to be misleading, and valueless for scientific purposes. In the present case, I have thought it the safer course to put the Yarmouth values out of consideration altogether in obtaining my final results.

One other instrument was available for testing the Scilly equivalents, namely, the pressure-tube anemometer, also erected in 1895, at Holyhead. Unlike the Robinson instrument at that station it occupies an excellent position, with a perfectly free exposure; and I have therefore used its records in the same way as those of the similar instrument at Scilly. Readings were taken for ten-minute intervals, and also for the hour; and the maximum and minimum forces recorded in the ten minutes were also noted. As the number of observations available was not very great I did not group them under directions of wind, but in view of the excellent position of the instrument I think this omission of no great importance. The mean results are shown in Table X.

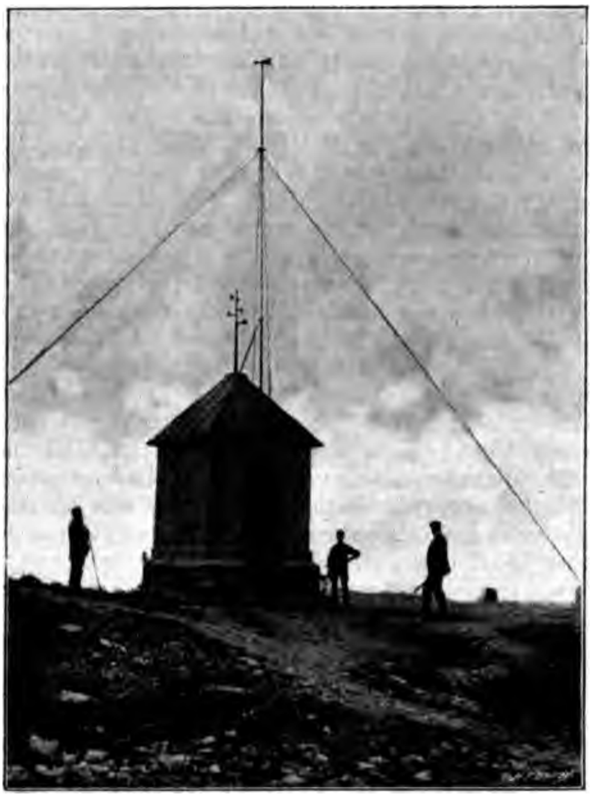

FIG. 4.—Pressure-Tube and Bridled Anemometers on Salt Island, Holyhead.

It will be seen at once that the equivalent velocities yielded by this instrument are very different from those of either of the other three stations. For forces 1 to 5 they are higher than Fleetwood, and up to force 3 they even exceed the mean *maximum* velocities as obtained from Scilly. For forces of 6 and upwards, however, this is reversed; the increment between forces 5, 6, and 7 is very small, and the equivalents from 6 up to 9 become in consequence less than at the other stations. When I first noticed this I inquired of Mr. Gaster, who has charge of the telegraphic reporting stations, whether he knew of any peculiarity in connection with the forces reported from Holyhead. Without knowing why the question was asked, he said, The observer under-estimates his light winds and over-estimates his strong winds, which explains completely the result shown by my comparison.

This peculiarity of the Holyhead observer may perhaps be due to "temperament," which, as I said early in this paper, is a factor not to be wholly lost sight of; or it may to some extent be due to the fact that, as yet, his experience is more limited than that of the other men whose observations I have used; but it is remarkable that Mr. Scott's values, which were mainly based on Holyhead observations, made, however, with another instrument, and by another observer, should show an almost precisely similar feature. Mr. Scott's equivalents for the lightest winds, corrected for factor to 2·2, were higher than those now obtained from Holyhead; for forces 3 to 5 they were the same; and for force 6 and upwards again higher; but when they are compared with the Scilly equivalents the differences between the two sets change *sign* at just the same force (5-6) as when the present Holyhead values are compared with Scilly.

Before leaving this I may mention that in the nearly sixteen years' observations made at Scilly, force 12 was never once observed at any of the three hours per diem at which the force of wind was recorded. At Yarmouth, in the twenty-six years, the highest force reported with a wind blowing from between North and South-east was 9. At Fleetwood during eight years force 12 was reached only during the memorable gale of December 1894, during which the lightship broke away from her moorings; and at Holyhead during one year force 9 was not exceeded.

The number of individual observations dealt with was as follows:—

Scilly	10,263
Yarmouth	5,857
Fleetwood	4,196
Scilly pressure-tube	1,101
Holyhead pressure-tube	944
Total	22,361

GENERAL CONCLUSIONS.

Bearing in mind the variable character of the element dealt with; the impossibility of strictly defining the scale by which the forces are to be gauged; the differences in the situations of the instruments, and in the surroundings of the observers; the fact that the estimations of several men were employed, and that none of them could compare or exchange their views upon the subject; and also that not only were the observers varied, but also that the instruments used differed in principle, as well as in make, and in dimensions;—I consider that the close agreement shown between the velocity equivalents obtained is not only most satisfactory but is really remarkable. I put aside here the Holyhead results, which I feel sure are abnormal, and due entirely to some personal bias on the part of the present observer there.

In the following table I have brought together the values found from the small-size Robinson, and the pressure-tube, anemometers at Scilly; and from the large (standard) size anemometers at Fleetwood and Yarmouth; and I also give the means of the four, obtained by giving equal weight to each value, irrespective of the number of observations upon which it is based. I also show the percentage of the difference of each value from this mean, and it will be seen that the percentages are only large with the lowest forces, where they represent differences which are really very small in amount.

TABLE XI.—MEAN EQUIVALENT VELOCITIES OBTAINED FROM OBSERVATIONS MADE AT SCILLY, FLEETWOOD, AND YARMOUTH; AND THE DIFFERENCE OF EACH MEAN FROM THE MEAN OF THE WHOLE, EXPRESSED AS A PERCENTAGE.

	Force by Beaufort's Scale.												
	0	1	2	3	4	5	6	7	8	9	10	11	12
lly (Robinson)	...	3·9	6·7	9·3	13·5	19·8	26·0	31·7	36·9	43·0	51·5	63·1	...
(P. Tube) .	...	2·9	6·0	9·0	13·9	19·2	24·7	30·8	38·6	44·6	55·0	67·0	...
etwood . .	...	4·6	8·0	11·3	15·8	20·7	26·2	31·8	37·9	44·1	52·7	59·9	74·1
rmouth . .	...	4·2	7·0	10·2	14·9	20·3	25·4	31·2	35·8	43·9	...	...	...
Mean . .	...	3·9	6·9	10·0	14·5	20·0	25·6	31·4	37·3	43·9	53·1	63·3	74·1
ifferences		%	%	%	%	%	%	%	%	%	%	%	%
lly (Robinson)	...	0	−2·9	−7·0	−6·9	−1·0	+1·6	+1·0	−1·1	−2·1	−3·0	−0·3	...
(P. Tube) .	...	−25·6	−13·0	−10·0	−4·1	−4·0	−3·5	−1·9	+3·5	+1·6	+3·6	+5·8	...
etwood . .	...	+17·9	+15·9	+13·0	+9·0	+3·5	+2·3	+1·3	+1·6	+0·5	−0·8	−5·4	0
rmouth . .	...	+7·7	+1·4	+2·0	+2·8	+1·5	−0·8	−0·6	−4·0	0	...	...	.

I have, however, gone carefully over all the values, having regard not only to the number of observations from which they were obtained, but also to every circumstance which I thought should have weight in judging of their relative worth; and as the result I submit the following as the most probable values of the mean true velocity equivalents for the forces of Beaufort's Scale:—

TABLE XII.—VELOCITY EQUIVALENTS FOR ESTIMATED FORCES BY BEAUFORT'S SCALE.

	Beaufort's Scale.												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Equivalent Mean Velocity in miles per hour . .	2	4	7	10	14	19	25	31	37	44	53	64	77
Metres per second .	0·9	1·8	3·1	4·5	6·3	8·5	11·2	13·9	16·5	19·7	23·7	28·6	34·4

The velocity equivalents obtained from the five instruments whose records have been used in making the comparison, and also the mean equivalents adopted, have been plotted together in the diagram (Fig. 5).

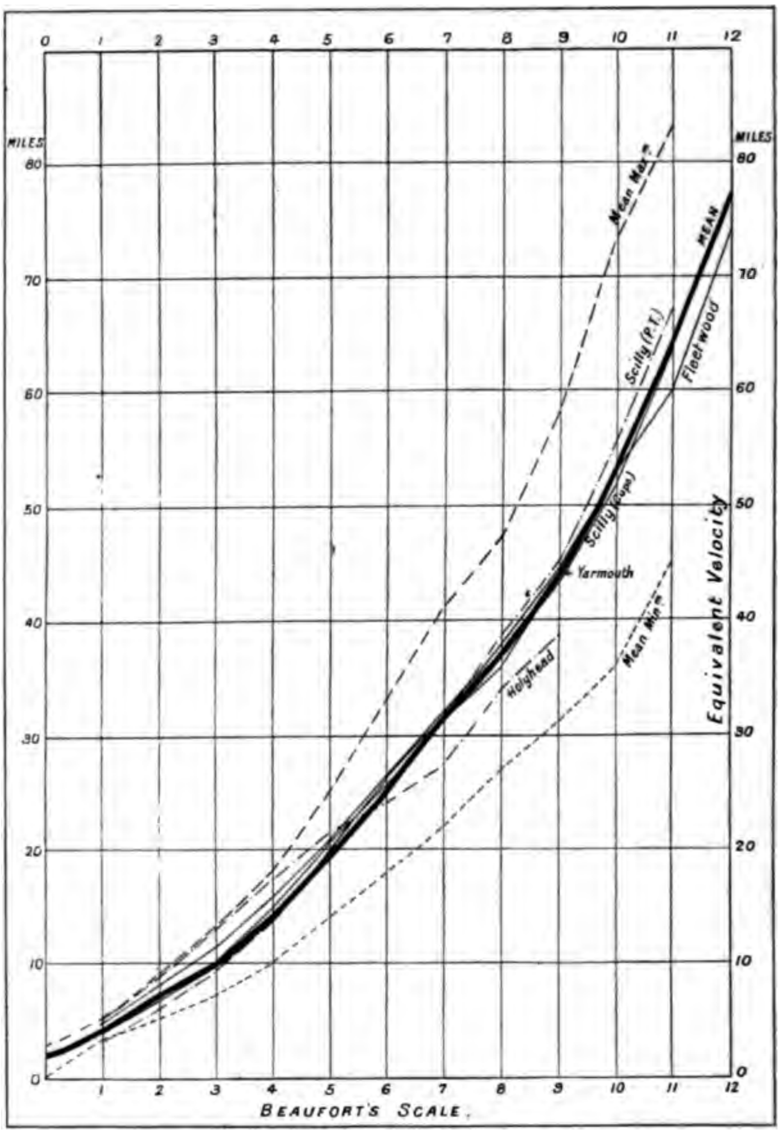

FIG. 5.—Diagram showing the Velocity Equivalents obtained from the several Anemometers, together with the adopted Mean Velocity Equivalents, and the Mean Range of Velocity.

The mean *range* of velocity for each force is probably indicated with a fair approach to the truth by the figures given in Tables V. and X. It must of course be understood that these do not purport to define the absolute limits beyond which the wind-force does not pass, but only the *average* range of its oscillations; and doubtless in squally winds, of a given average force, the limits here assigned to that force may frequently be overpassed.

The number of observations of range which was available was not so large as I could have wished, the pressure-tube instruments having been erected only about a year; but the observations were fairly consistent amongst themselves, and the mean values were only slightly modified by the inclusion of the later observations, added from time to time as they became available. The peculiarity of the Holyhead estimated forces, already referred to, affects the *actual values* of the extremes, but not necessarily the *extent of the range*. The maximum and minimum values both follow the same course as the mean velocity, and while they are above those of Scilly with light winds, they are less than those with winds of force 6 and above; but at the same time the actual mean range of the oscillations is shown by the figures to be much the same at both places. This will be seen from Table XIII.

TABLE XIII.—Average Oscillation of the Wind-Velocity with each Force of Beaufort's Scale.

		Estimated Force.												
	Miles per Hour	0	1	2	3	4	5	6	7	8	9	10	11	12
Total Range.	Scilly . . .	...	1·8	3·8	5·4	8·0	11·1	14·4	18·5	22·9	27·1	35·0	33·0	...
	Holyhead . .	...	2·3	4·0	5·8	8·4	10·8	12·4	16·2	18·9	23·5	...	...	...
	Mean . . .	...	2·05	3·9	5·6	8·2	10·95	13·4	17·35	20·9	25·3	35·0	33·0	...
Maxima.	Scilly . . .	...	0·9	1·8	2·6	3·7	5·2	6·9	8·9	12·8	13·2	15·0	14·0	?
	Holyhead . .	...	1·1	1·9	2·7	4·1	5·3	5·8	8·1	9·3	11·9	...	...	...
	Mean . . .	...	+1·0	1·9	2·7	3·9	5·3	6·4	8·5	11·1	12·6	15·0	14·0	?
Minima.	Scilly . . .	...	0·9	2·0	2·8	4·3	5·9	7·5	9·6	10·1	13·9	20·0	19·0	?
	Holyhead . .	...	1·2	2·1	3·1	4·3	5·5	6·6	8·1	9·6	11·6	...	...	...
	Mean . . .	...	−1·1	2·1	3·0	4·3	5·7	7·1	8·9	9·9	12·8	20·0	19·0	?
	Average Max. Veloc.	...	5	9	13	18	25	33	41	47	58	73	83	?
	Mean Vel. (Table XII.)	2	4	7	10	14	19	25	31	37	44	53	64	77
	Average Min. Veloc.	0	3	5	7	10	14	18	22	27	31	36	45	?

It is important to remember that throughout this work I have used what I believe to be *true* wind velocities, and the velocities recorded by an anemometer can only be referred to the equivalents I have given when the factor of the anemometer is known. The scale of the pressure-tube instrument is based upon the results of Mr. Dines' Hersham experiments; and the factor for the Robinson anemometer at Scilly having been determined by a comparison of its indications with those of the pressure-tube, it may also be said to rest on the same basis. The factor I have used for the large (standard) pattern Robinson anemometers at Fleetwood and Yarmouth is that obtained by direct experiments on the large whirling apparatus at Hersham, and the close agreement of the velocity equivalents found for the Beaufort scale at those different places goes far to confirm the accuracy of the Hersham results.

The practice of continuing to quote velocities based on a factor which is known to be erroneous appears to me to be quite indefensible. It is clear that it gives rise to trouble, uncertainty, and to error; and it seems to me to be the duty of all who have to deal with these matters to discontinue it at once.

There is no longer any doubt either as to the error of the old, universal factor, 3, or as to what is the correct factor for the large standard-size instrument. Not to mention the earlier investigations, the question was conclusively settled by the Hersham experiments. But the results Mr. Dines obtained there have since been amply confirmed by the very carefully-arranged and comprehensive series of experiments carried out at the Blue Hill Observatory by Mr. A. L. Rotch, B.Sc., and his coadjutor Mr. S. P. Fergusson. More recently there has been added an additional confirmation, in the results of a comparison made at Rousdon by Mr. Cuthbert E. Peek, M.A., between a cup anemometer of the standard size and a recording pressure-tube instrument, exposed under similar conditions, which gives precisely the same value, 2·2, for the factor.[1]

Whilst engaged upon this work I sought for information as to the equivalent velocities for wind-scales, which had hitherto been published. This search I found a rather difficult one, and I have thought it might serve a useful purpose to put together, in a condensed form, the information which I gathered, and to give it as an Appendix to this paper. For this purpose I extended the scope of my search, so as to embrace, as far as I could, information as to the various wind-scales in use in different countries, whether with velocity equivalents or not. To some extent, this has already been done by Mr. C. Harding (*Quarterly Journal*, vol. xi.); but I thought the advantage of making the list as complete as possible might justify me in again going over the ground he had covered, and I have been a good deal assisted by the work he did. I have also given pressure equivalents in some instances; but generally I found it was upon the pressures that the velocities are based. The usual practice seems to have been to assign, empirically, a pressure as the equivalent of a certain force by the scale in question, and then to convert the pressure into velocity by one or other of the many formulæ extant. The diversity of result obtained will, I think, prove a justification for the labour expended on the present attempt to determine the velocity equivalents by a direct comparison with the anemometrical observations.

In conclusion, I beg to acknowledge the kindness of the Meteorological Council, who readily granted me free use of the anemometrical data in their possession; of the Trinity House for the loan of several years' logs of the Morecambe Bay and St. Nicholas lightships, and the St. Agnes Lighthouse; and of the Fleetwood Harbour Commissioners for their offer of help, of which, however, I was not able to avail myself. Also, I wish to acknowledge my indebtedness to my friends Mr. C. H. Thompson, Mr. T. D. Bell, and Mr. L. H. Powers, all of the staff of the Meteorological Office, for much valuable help, very readily given, which greatly assisted me in dealing with so large a mass of observations, and in preparing Tables XIV. to XVIII. in the Appendix.

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[1] *Report of the Rousdon Observatory* for 1895, p. 25.

TABLE XIV.—SCALES OF WIND-FORCE BASED UPON THE SAIL-CARRYING POWER, OR UPON THE SPEED, OF A SHIP, WITH THEIR EQUIVALENT WIND-VELOCITIES; IN ORDER OF DATE OF PUBLICATION.

(Unless otherwise stated the Scale is in each case from 0 to 12, and the Sail Equivalents, or the descriptions of the Wind, if they were given, were those of Admiral Beaufort, and therefore have not been repeated here.)

Scale of Wind-Force.	[1] BEAUFORT, 1805.			[2] SNOW HARRIS, 1857?	
	Description.			Velocity, miles per hour.	Description.
0	Calm.			0·68 to 1·06	Gentle breathing airs.
1	Light air, or just sufficient to give steerage way.			2·0 - 3·3	Extremely light airs; would fill a light balloon calico sail of a small yacht.
2	Light breeze	or that in which a well-conditioned man-of-war with all sail set, and "clean full," would go in smooth water from	1 to 2 knots.	3·8 - 7·6	Light gentle breezes; would fill the light sails of a large ship aloft, or light duck sails; usually called gentle breezes.
3	Gentle ,,		3 to 4 ,,	8·0 - 12·0	Moderate fresh breezes, ships carry a crowd of sail
4	Moderate ,,		5 to 6 ,,	13·0 - 16·5	Moderately strong breezes, top-gallant sails and royals.
5	Fresh ,,	or that to which she could just carry in "chase," "full and by"	Royals, etc.	17·0 - 18·0	Fresh winds; top-gallant breezes.
6	Strong ,,		Single-reefed topsails or top-gallant sails.	18·67 - 20·0	Very fresh winds and moderate gales; whole and reefed topsail breezes.
7	Moderate gale		Double-reefed topsails, jib, etc.	20·14 - 24·0	Strong winds and gales; double-reefed topsails and courses.
8	Fresh ,,		Triple-reefed topsails, etc.	26·40 - 34·0	Very strong winds and storms; close-reefed top-sail gales.
9	Strong ,,		Close-reefed topsails and courses.	34·0 - 59·0	Heavy gales and storms.
10	Whole gale, or that with which she could scarcely bear close-reefed main topsail and reefed foresail.			59·0 - 83·6	Very heavy gales, storms, tempests.
11	Storm, or that which would reduce her to storm stay-sails.			90·12 - 90·34	Hurricanes, extremely heavy gales and tornados.
12	Hurricane, or that which no canvas could withstand.			107·7 - 120·0	Violent hurricanes which blow down buildings.

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[1] Admiral Sir F. Beaufort devised this scale for use on board H.M.S. *Woolwich* in 1805 (*Weather Book*, p. 31, and *Instructions in the Use of Meteorological Instruments*, 1875).
[2] Sir W. Snow Harris, F.R.S., deduced this scale "by a careful review of the best experiments on record." *Pamphlet on a New Form of Anemometer*, published by Lilley & Son, London.

TABLE XIV.—SCALE OF WIND-FORCE—*Continued*.

Scale of Wind-force.	[3] SCHOTT, 1861.	[4] JAMES, 1861.	[5] FITZROY, 1863.	[6] SYMONS, 1866.		[7] JELINEK, 1869.	[8] BUCHAN, 1871.	[9] BOARD OF TRADE, 1872.	[10] LAUGHTON, 1873.	[11] SCOTT, 1874.
	Velocity, miles per hour.	Velocity, miles per hour.	Velocity, miles per hour.	Velocity, miles per hour.	Popular Description.	Velocity, English miles per hour.	Velocity, miles per hour.	Velocity, miles per hour.	Velocity, miles per hour.	Velocity, miles per hour.
0	0	0	...	0	Calm.	0	0·0	0 to 2	0	0 to 5
1	1	7	...	8	Gentle breeze.	2	7·1	3 10	2	6 10
2	4	14	5	14	Moderate ,,	3	14·1	11 15	4	11 15
3	10	21	10	21	Fresh ,,	5	21·2	16 20	8	16 20
4	17	28	18	28	Very fresh.	7	28·3	21 25	16	21 25
5	24	35	25	35	Strong.	12	35·4	26 30	24	26 30
6	32	42	33	42	High wind.	15	42·4	31 36	32	31 36
7	40	49	40	50	Moderate gale.	22	49·5	37 44	40	37 44
8	48	57	55	57	Gale.	31	56·6	45 52	50	45 52
9	56	64	63	64	Fresh gale.	37	63·6	53 60	62	53 60
10	67	71	70	71	Strong ,,	43	70·7	61 69	78	61 69
11	82	78	78	78	Storm.	57	77·8	70 – 80	96	70 80
12	100	85	85	85	Hurricane.	68	84·8	above 80	120	80 and upwards. (He also gives the same figures as in col. 10.)

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[3] Discussion of Sir F. M'Clintock's observations in the *Fox*. *Smithsonian Contributions*, vol. xiii. No. 146, p. 39. These equivalents were derived from a 0 to 10 scale by simple proportion.

[4] *Instructions for taking Meteorological Observations*, by Col. Sir Henry James, R.E., F.R.S.

[5] These values were given by Mr. C. Harding, *Quarterly Journal Roy. Met. Soc.*, vol. xi. 1885; they were "obtained by substitution from the figures given" by Admiral FitzRoy in *The Weather Book*, p. 38.

[6] *Symons's Monthly Meteorological Magazine*, April 1866, p. 20.

[7] *Austrian Instructions for keeping Meteorological Observations*, p. 68. Copied from *Quarterly Journal Roy. Met. Soc.*, vol. xi. 1885.

[8] *Introductory Text-Book of Meteorology*, p. 131.

[9] *Board of Trade Circular, No.* 558, July 1872. *Instructions to Receivers of Wreck and Officers of Coast-Guard.*

[10] *Physical Geography*, p. 4.

[11] *Quarterly Journal Roy. Met. Soc.*, vol. ii. p. 112.

TABLE XIV.—SCALE OF WIND-FORCE.—*Continued.*

Scale of Wind-force.	[12] Meteorological Office, 1875.	[13] Meteorological Office, 1876.	[14] Deutsche Seewarte, 1876.		[15] White, 1877.	[16] Wyville Thomson, 1877.	[17] Wyman, 1878.
	Velocity, miles per hour.	Description.	Description.	Velocity, miles per hour.	Velocity, miles per hour.	Velocity, miles per hour.	Velocity, miles per hour.
0	3	Same as Beaufort.	Calm, or very light air.	3	...	...	...
1	8	,,	Light air . . .	8	...	1·5	1 2
2	13	,,	Slight wind . . .	13	...	2	4
3	18	,,	Gentle wind . .	18	...	4·5	9
4	23	,,	Moderate wind . .	23	...	8	14
5	28	,,	Fresh wind . . .	28	16	12·5	17
6	34	Top-gallant sails.	Strong wind . .	34	20	18	20
7	40	Topsails, jib, etc.	Very strong wind .	40	26	24·5	24
8	48	Reefed upper topsails and courses.	Stormy wind . .	48	31	32	30
9	56	Lower topsails and courses.	Storm	56	...	40·5	40
10	65	Lower main-topsail and reefed foresail.	Heavy storm . .	65	...	50	67
11	75	Same as Beaufort.	Severe storm . .	75	...	61	80
12	90	,,	Hurricane . . .	90	...	72	100 and upwards.

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[12] *Instructions in the Use of Meteorological Instruments.* This scale of velocities "must be considered as merely provisional."

[13] This modification was introduced by Capt. H. Toynbee, F.R.A.S., to meet the changes in the rig of ships since Admiral Beaufort's time.

[14] *Instruction zur Führung des Meteorologischen Journals der Deutschen Seewarte*, p. 22.

[15] White's *Naval Architecture*, p. 473. Copied from Dr. Köppen, *Quart. Jour. Roy. Met. Soc.*, vol. xi. p. 268.

[16] *The Voyage of the Challenger*, p. 161. The anemometer used was one of the small instruments supplied by the Meteorological Office. (Mr. Scott, *Quart. Jour. Roy. Met. Soc.* vol. xi. p. 47.)

[17] Washington Hydrographic Office. *Meteorological Log*, p. 7. Copied from Mr. C. Harding, *Quart. Jour. Roy. Met. Soc.*, vol. xi. p. 41.

TABLE XIV.—Scale of Wind-Force—*Continued.*

Scale of Wind-force.	[18] Dictionary, 1878.	[19] U.S. Hydrographic Office, 1878.			
	Velocity, feet per second.	Nautical Designation.	Sail that a full-rigged ship may carry, close hauled by the wind; also her probable speed.	Sail that a full-rigged ship may carry, wind on quarter; also her probable speed.	Velocity, miles per hour.
0	4·40	Calm . . .	All sail	All sail	0
1	12·0	Light airs . .	All plain sail, stay-sails; smooth sea; 0·5 to 1 knot per hour.	All plain sail and studding sails; smooth sea; 1 to 1·5 knots per hour.	1 to 2
2	19·0	Light breezes .	All plain sail, stay-sails; smooth sea; about 2 knots.	All plain sail and studding sails; smooth sea; 2 to 3·5 knots.	4
3	26·0	Gentle breezes .	All plain sail, stay-sails; smooth sea; 3 to 4 knots.	All plain sail and studding sails; smooth sea; 4 to 5 knots.	9
4	39·0	Moderate breezes.	All plain sail and stay-sails; 5 to 6 knots . .	All plain sail and studding sails; smooth sea; 6 to 7 knots.	14
5	41·0	Stiff breezes .	All plain sail, top-gallant sails, stay-sails; moderate sea; 6 to 7 knots.	All plain sail and studding sails; moderate sea; 8 to 9 knots.	17
6	50·0	Fresh breezes .	Courses, single-reefed topsails, top-gallant sails, moderate sea, 7 to 9 knots.	All plain sail to top-gallant sails, lower and top-mast studding sails; moderate sea; 10 to 12 knots.	20
7	59·0	Very fresh breezes	Courses, double-reefed topsails, fore topmast stay-sails; moderate sea; *about* 7 knots.	Courses, single-reefed topsails, top-gallant sails; moderate sea; 12 to 14 knots.	24
8	70·0	Moderate gale .	Single-reefed fore and main topsails, close-reefed mizzen, fore topmast stay-sail; rough sea; 4 to 5 knots.	Single-reefed courses, double-reefed fore and main topsails, close-reefed mizzen; rough sea; about 10 knots.	30
9	82·0	Strong gale . .	Close-reefed courses, close-reefed fore and main topsails, storm stay-sails; rough sea.	Close-reefed courses, close-reefed fore and main topsails, storm stay-sails; rough sea.	40
10	95·0	Very strong gale .	Close-reefed foresail, close-reefed main topsail, fore storm stay-sail; very rough sea.	Close-reefed foresail, close-reefed main topsail, fore storm stay-sail; very rough sea.	67
11	110·0	Violent gale .	Storm sails, or close-reefed main topsail and fore storm stay-sail; very rough sea.	Close-reefed foresail, close-reefed main topsail, fore storm stay-sails.	80
12	132·0	Hurricane . Typhoon . Cyclone .	None; lying-to; drifting bodily to leeward .	Scudding under bare poles	100 and upwards.

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[18] *Technological Dictionary*, p. 746.

[19] *Meteorological Journal*, Washington, 1878. This scale has been copied into the Swedish Meteorological log. (Harding, *Quart. Jour. Roy. Met. Soc.*, vol. xi. p. 42.)

TABLE XIV.—SCALE OF WIND-FORCE—*Continued.*

Scale of Wind-force.	[20] SPRUNG, 1879.	[21] SPRUNG, 1881.		[22] MOHN, 1883.			[23] CHATTERTON, 1877.
	Velocity, metres per sec.	Velocity in metres per second.		Velocity, miles per hour.	Description.	Land Scale Equivalents.	Velocity, miles per hour.
		N. through E. to S.S.E.	S. through W. to N.N.W.				
0	...	...	...	3	No motion	1	4·9
1	2·64	2·1	2·0	8	Steerage way		6·5
2	3·99	3·7	3·8	13	1 to 2 knots	2	7·8
3	5·34	5·3	5·6	18	2 to 4 „		11·6
4	6·70	6·9	7·3	23	4 to 6 „	3	17·0
5	8·05	8·5	9·1	28	Royals		22·9
6	9·41	10·1	10·9	34	Single-reefed main topsail, and top-gallant sails .	4	28·3
7	10·76	11·7	12·7	40	Double-reefed main topsail	5	35·4
8	12·11	13·8	14·5	48	Triple-reefed main topsail		41·6
9	...	...	...	56	Close-reefed main topsail		46·0
10	...	...	...	65	Single-reefed main-sail	6	52·1
11	...	...	...	75	Storm stay-sail		...
12	...	...	...	90	No sails		...

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[20] *Aus dem Archiv der Deutschen Seewarte*, vol. ii. No. 2, p. 24. These values are the approximate true wind velocities deduced according to the equation $w=1.0+0.8\,w'$.

[21] *Zeitschrift der Österreichischen Gesellschaft für Meteorologie*, vol. xvi. p. 358. The records of four stations were used in this investigation, using factor 3. In 1855 Dr. Köppen reduced the values to factor 2.4, with a friction constant of 0.3 metre per second. *Quarterly Journal Roy. Met. Soc.* vol. xi. p. 268.

[22] *Grundzüge der Meteorologie*, p. 145.

[23] Report of the Wind-Force Committee, *Quarterly Journal Roy. Met. Soc.* vol. xiii. p. 215. These values were obtained by comparison between the records of the anemograph at Holyhead, and the entries of Beaufort scale in the log kept on board the Carnarvon Bay Lightship, which Mr. Chatterton thought "give a regular and probably the most reliable curve of all." The result of other comparisons are given, but the Committee could not "recommend any existing scale that should be adopted or modified."

TABLE XIV.—SCALE OF WIND-FORCE—*Continued.*

Scale of Wind-Force.	[24] WALDO, 1887.						[25] SCOTCH LOG-BOOK.			[26] KRÜMMEL, 1892.		
	Miles per hour.											
	Scott's data reduced by Köppen.	Sprung's results given by Köppen.	Köppen's formula, from Cols. 2 and 3.	Waldo's results. Mean of three anemometers on board ship.	Waldo's results, using anemometer on wheel-house only.	Scott's results reduced by same formula as Sprung's and Waldo's.	Force.	Description.	Sail that can be carried.	Force.	Miles per hour.	Metres per second.
0	4·70	4·25	3·71	...	...	...	0	Calm . . .	All square sails and studding sails set.	0	...	...
1	6·49	6·04	6·30	7·83	7·83	8·72	1	Light airs . .	All plain sail set.	1	...	...
2	9·40	8·95	9·13	11·86	10·29	12·53	2	Light breeze .	Courses, topsails and topgallant sails set.	2	7·6	3·4
3	11·86	12·08	12·15	14·32	12·53	16·55	3	Smart breeze .	Single reefs and topgallant sails over.	3	11·4	5·1
4	15·44	15·21	15·34	16·55	15·88	20·58	4	Fresh breeze .	Single reefs and topgallant sails in.	4	15·9	7·1
5	19·46	18·34	18·77	19·91	20·58	24·61	5	Strong breeze .	Double reefs in. Jib and spanker set.	5	21·0	9·4
6	23·94	21·92	22·37	26·17	27·74	29·08	6	Moderate gale .	Double reefs. Jib and spanker in.	6	26·2	11·7
7	28·41	23·94	26·17	30·20	34·23	34·67	7	Fresh gale . .	Double reef topsails and reefed courses.	7	31·8	14·2
8	32·44	27·74	30·20	35·79	36·69	40·94	8	Strong gale . .	Close-reefed and courses in.	8	36·2	16·2
9	35·12	33·33	34·41	42·28	39·82	47·42	9	Whole gale . .	Hove to.			
10	...	...	...	...	...	...	10	Storm or Hurricane	No sail set.			
11	...	...	...	...	...	...						
12	...	...	...	...	...	...						

[24] *American Meteorological Journal*, vol. iv. p. 274.

[25] This scale is printed on the cover of many log-books used by large steamships sailing out of Scotch ports. (Wm. Allingham, *The Nautical Magazine*, March 1896.)

[26] *Plankton-Expedition der Humboldt-Stiftung*, Band I., Sec. C., von Dr. Otto Krümmel, 1892.

[1] KAEMTZ, 1845.

Force.	Description of Wind.
0	Gentle wind (slight breeze).
1	Moderate wind (brisk breeze).
2	Strong wind (fresh breeze.)
3	Violent wind (strong gale).
4	Storm and tempest.

[2] THOMSON, 1849.

Velocity, miles per hour.	Description of Wind.
1	Hardly felt.
2 3	Light breeze, barely perceptible.
4 5	Gentle breeze.
10 15	Brisk, pleasant, gale.
20 25	Very brisk gale,—*fresh*.
30 35	High wind or strong gale.
40 45	Very high wind or hard gale.
50 60	Hurricane, tempest.
80 100	Violent hurricane, tearing up trees, overturning buildings, etc.

[3] DREW, 1855.

Pressure, lbs. per square foot.	Description of Wind.
0	Calm.
0·26	Pleasant wind.
0·52	Fresh breeze.
2·6	Brisk gale.
5·21	High wind.
10·42	Very high wind.
15·62	Storm.
20·83	Great storm.
26·04	Very great storm.
31·75	Hurricane.

[4] SCHOTT, 1861.

Pressure, lbs. per square foot.	Velocity, miles per hr.	Description of Wind.
0·000	0	Calm.
0·005	1	Light air.
0·08	4	Gentle breeze.
0·9	13	Moderate breeze.
2·6	23	Fresh breeze.
5·1	32	Strong breeze.
7·9	40	Fresh gale.
12·0	50	Strong gale.
18·0	60	Storm.
31·0	80	Tempest.
49·0	100	Hurricane.

[5] HERSCHEL, 1862.

Velocity, miles per hour.	Description of Wind.
7	Gentle air.
14	Light breeze.
21	Good sailing breeze.
41	Gale.
61	Great storm.
82	Tempest.
92	Hurricane.

[6] GLAISHER, 1863?

Force.	Description of Wind.	Beaufort Equivalents.
1	Moderate .	1 – 2
2	Fresh . .	3 – 4
3	Strong . .	5 – 6
4	Heavy . .	7 – 8
5	Violent . .	9 – 10
6	Tremendous .	11 – 12

[7] GLAISHER, 1863.

Estimated Force.	Description of Wind.
0.0	Calm.
0.1 0.2	Very light airs.
0.3 0.4 0.5	Light breeze.
0.6 0.7 0.8	Moderate breeze.
0.9 1.0 1.1	Fresh breeze.
1.5 2.0 2.5	Very fresh wind.
3.0 3.5	Strong wind, gale.
4.0	Strong gale.
5.0	Heavy gale.
6.0	Hurricane.

[8] FITZROY, 1863.

Sea Scale.	Character of Wind.	Land Scale.	Velocity, miles per hour.
1 to 3	Light . . .	0 to 1	10
3 – 5	Moderate . .	1 – 2	25
5 – 7	Fresh . .	2 – 3	40
7 – 8	Strong . .	3 – 4	55
8 – 10	Heavy . .	4 – 5	70
10 – 12	Violent . .	5 – 6	85

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[1] Kaemtz's *Meteorology*, translated by C. V. Walker, p. 29 (1845).

[2] *Introduction to Meteorology*, by D. P. Thomson, M.D., p. 378.

[3] *Practical Meteorology*, by John Drew, Ph.D., F.R.A.S., p. 113. This scale is based on results from Lind's Wind-gauge.

[4] Discussion of Sir F. M'Clintock's observations on board the *Fox*. *Smithsonian Contributions*, vol. xiii. No. 146, p. 39. This table was used to obtain the equivalents for Beaufort's scale (see Table I.).

[5] Herschel's *Meteorology*, pp. 55-56.

[6] Taken from *Ocean Meteorology*, by Findlay, edited by W. R. Martin, R.N.

[7] *Weather Book*, p. 42.

[8] *The Weather Book*, p. 38.

TABLE XV.—Scale of Wind-Force—*Continued.*

9 Buchan, 1867.

Estimated Force.	Velocity, miles per hour.	Description of Wind.
0·0	0·0	Calm.
0·1	1·4	Lightest breath of air.
0·5	7·1	Very light air.
1·0	14·1	Light air.
1·5	21·2	Light breeze.
2·0	28·3	Fresh breeze.
2·5	35·4	
3·0	42·4	Very fresh.
3·5	49·5	
4·0	56·6	Blowing hard.
4·5	63·6	
5·0	70·7	Blowing a gale.
5·5	77·8	Violent gale.
6·0	84·8	Hurricane.

10 Buchan, 1871.

Scale 0 to 6.	Velocity, miles per hour.	Beaufort Equivalents.	Description of Wind.
0·0	0·0	0	Calm.
0·5	7·1	1	Light air.
1·0	14·1	2	Light breeze.
1·5	21·2	3	Gentle breeze.
2·0	28·3	4	Moderate breeze.
2·5	35·4	5	Fresh breeze.
3·0	42·4	6	Strong breeze.
3·5	49·5	7	Moderate gale.
4·0	56·6	8	Fresh gale.
4·5	63·6	9	Strong gale.
5·0	70·7	10	Whole gale.
5·5	77·8	11	Storm.
6·0	84·8	12	Hurricane.

11 Wild, 1873.

Usual designation of the Wind.	Velocity, miles per hour.
Very light breeze . .	2·2
Light	4·4
Gentle	6·7
Moderate . . .	9
Moderately fresh . .	11
Fresh	13
Very fresh . . .	16
Moderately strong . .	18
Strong	20
Very strong . . .	22
Rather violent . .	27
Violent	31
Very violent . .	36
Moderate storm . .	40
Storm	45
Heavy storm . . .	51
Moderate hurricane .	58
Hurricane . . .	67
Violent hurricane . .	79

12 Dictionary, 1878.

Land Scale.	Description of Wind.	Beaufort Equivalents.	Velocity, feet per sec.
0	Calm .	0 – 1	0·13
1	Light .	1	14·7
2	Moderate	2	36·7
3	Fresh .	3 – 4	58·7
4	Strong .	5 – 6	80·7
5	Heavy .	7 – 9	102·7
6	Violent .	10 – 12	127·4

13 Kingston, 1878.

Force.	Description of Wind.	Approximate Velocity, miles per hour.
0	Calm or light air	Not exceeding 2
1	Light air . .	Above 2 and not exceeding 4
2	Light breeze .	,, 4 ,, 8
3	Moderate breeze	,, 8 ,, 16
4	Fresh breeze .	,, 16 ,, 25
5	Strong breeze .	,, 25 ,, 34
6	Moderate gale .	,, 34 ,, 44
7	Fresh gale .	,, 44 ,, 55
8	Strong gale .	,, 55 ,, 67
9	Heavy or whole gale	,, 67 ,, 80
10	Hurricane .	,, 80 miles.

14 French Telegraphic Code, 1879.

Force.	Description of Wind.
0	Calm.
1	Nearly calm.
2	Very light.
3	Light.
4	Moderate.
5	Rather strong.
6	Strong.
7	Very strong.
8	Violent.
9	Tempest.

15 Mascart, 1883.

Force.	Description of Wind.	Approx. Veloc., Kilometres per hour.
0	Calm . .	0
1	Light . .	7
2	Moderate .	25
3	Rather strong.	40
4	Strong . .	60
5	Very strong .	75
6	Tempest .	100
7	Hurricane .	160

[16] MOHN, 1883.

Land Scale.

Force.	Description of Wind.	Metres per second.
0	Calm .	0 to 0·5
1	Light .	0·5 – 4
2	Moderate .	4 – 7
3	Fresh .	7 – 11
4	Strong .	11 – 17
5	Storm .	17 – 28
6	Hurricane .	over 28

[17] CHASE, 1884.

Force.	Description of Wind.	Velocity, miles per hour varies between
0	Calm	...
1	Very light breeze .	1 and 2
2	Gentle breeze . .	3 – 5
3	Fresh breeze . .	6 – 14
4	Strong wind . .	15 – 24
5	High wind . . .	25 – 39
6	Gale	40 – 59
7	Strong gale . .	60 – 69
8	Violent gale . .	70 – 79
9	Hurricane . . .	80 – 99
10	Most violent hurricane	100 and upwards

[18] SIGNAL SERVICE SCALE, 1887.

Description of Wind.	Velocity, miles per hr.	Description.
Calm .	0	No visible horizontal motion to inanimate matter.
Light .	1 to 2	Causes smoke to move from the vertical.
Gentle .	3 – 5	Moves leaves of trees.
Fresh .	6 – 14	Moves small branches of trees and blows up dust.
Brisk .	15 – 24	Good sailing breeze, and makes white caps.
High .	25 – 39	Sways trees and breaks small branches.
Gale . .	40 – 59	Dangerous for sailing vessels.
Storm .	60 – 79	Prostrates exposed trees and frail houses.
Hurricane .	80 or more	Prostrates everything.

[19] SIGNAL SERVICE, 1887.

Force.	Description of Wind.
0	Calm.
1	Light; just moving the leaves of trees.
2	Moderate; moving branches.
3	Brisk; swaying branches, blowing up dust.
4	High; blowing up twigs from the ground, swaying whole trees.
5	Gale; breaking small branches, loosening bricks on chimneys.
6	Hurricane or tornado; destroying everything in its path.

[20] DAVIS, 1894.

Force.	Description of Wind.	Average Velocity, miles per hour.	Force.	Description of Wind.
0	Calm	0	1	Light wind.
1	Very light breeze .	2	2	Moderate wind.
2	Gentle breeze . .	7 or less	3	Strong wind.
3	Fresh breeze . .	11	4	Fresh gale.
4	Strong wind . .	18 or more	5	Whole gale.
5	High wind . . .	27	6	Hurricane.
6	Gale	36		
7	Strong gale . .	45		
8	Violent gale . .	58		
9	Hurricane . . .	76		
10	Most violent hurricane	95		

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[16] *Grundzüge der Meteorologie*, p. 145.

[17] *Elements of Meteorology*, by Pliny E. Chase, LL.D., part i. p. 10.

[18] *General Instructions to Observers of the Signal Service*, U.S.A., 1887, p. 49.

[19] *Instructions to voluntary Observers of the Signal Service*, U.S.A., 1887, p. 294. The forms furnished to voluntary observers have a scale of 0 to 10, but since many have found it difficult to use that scale the above is given.

[20] *Elementary Meteorology*, by Professor Davis, p. 94. The 0 to 10 scale is recommended.

TABLE XVI.—VARIOUS SCALES OF WIND-FORCE, WITH EQUIVALENT VELOCITIES OR PRESSURES, OR WITH CORRESPONDING FORCES BY OTHER SCALES; IN ORDER OF DATE OF PUBLICATION.

[1] FITZROY, 1863.		[2] GLAISHER, 1863.		[3] CATOR, 1874.		[4] WILD, 1875.		[5] MOHN, 1877.		[6] FRENCH SCALE, 1879.		[7] QUOTED BY MR. HARDING, 1884. Equivalent Velocities by the:		
Force.	Velocity, miles per hour.	Estimated force.	Pressure per sq. ft.	Force.	Velocity, miles per hour.	Force.	Velocity, metres per sec.	Force.	Velocity, metres per sec.	Force.	Velocity, metres per sec.	Force.	U.S. Signal Office. Scale in miles per hr.	U.S. Hydrographic Office. Scale in miles per hr.
1	10	0·25	1 oz.	1	8	1	2	0	0·1	0	0 to 0·5	1 and 2	0 to 9	0 to 9
2	25	0·5	4 ,,	2	16	2	3½	1	3·3	1	0·5 – 4	3 – 4	9·1 – 22·5	9·1 – 18·2
3	40	0·75	9 ,,	3	24	3	4½	2	5·9	2	4 – 7	5 – 6	22·6 – 40·5	18·3 – 28·8
4	55	1·0	1 lb.	4	32	4	6	3	10·0	3	7 – 11	7 – 8	40·6 – 67·5	28·9 – 69·6
5	70	1·5	2¼ ,,	5	40	5	7½	4	13·8	4	11 – 17	9 – 10	67·6 and upwards.	69·7 and upwards.
6	85	2·0	4 ,,	6	48	6	9	5	16·9	5	17 – 28			
		2·5	6¼ ,,	7	56	7	11			6	28 & above			
		3·0	9 ,,	8	64	8	about 14							
		3·5	12¼ ,,	9	72	9	about 19							
		4·0	16 ,,	10	80									
		4·5	20¼ ,,	11	88									
		5·0	25 ,,	12	96									
		6·0	36 ,,											

[8] QUOTED BY KÖPPEN, 1885.							[9] OMOND, 1893.		[10] QUOTED BY WALDO, 1893. Equivalents of the U.S. Scale in:								
The degrees of the 12 part scale (German coast).	Equivalents of the 12 part scale in the:			Degrees of Force of the 10 part scale.	Equivalent Velocities of the 10 part scale in metres per second:		Estimated Force.	Velocity, miles per hour.	U.S. Weather Bureau Scale 0 – 10.	Beaufort Scale 0 – 12.	Jelinek's Austrian Scale 0 – 10.	Wild's Russian Scale 0 – 10.	Old Russian Scale.	French Met. Ass'n Scale 1 – 7.	Paris Met. Bureau Scale 0 – 6.	English Land Scale 0 – 6.	Mannheim Scale. 0 – 4.
	10 part scale (Russia).	6 part scale (Norway).	12 part scale (Met. Office).		By Wild's plate.	By Mielberg.											
1	1·5	0·8	0·5	1	2	2·3	0	2	0	0	0	0	0	0	0	0	0
2	2·5	1·3	1·2	2	3½	3·6	1	7	1	0·5 – 1	...	1	0	1	1	0	...
3	3·6	1·8	1·8	3	4½	5·0	2	13	2	1·5 – 2	1	2	1	2	...	1	1
4	4·5	2·2	2·4	4	6	6·4	3	21	3	2·5 – 3	...	3	1	3	2	...	1 to 2
5	5·5	2·6	3·1	5	7½	7·8	4	29	4	3·5 – 4	2	4	2	4	3	2	2
6	6·4	3·0	3·8	6	9	9·3	5	38	5	4·5 – 5	3	5	2	...	...	...	...
7	6·9	3·2	4·2	7	11	10·7	6	47	6	5·5 – 6	4	6	3	5	4	3	3
8	7·5	3·6	5·0	8	14	12·1	7	57	7	7	5	7	3	...	...	4	...
							8	67	8	7·5 – 9	6 – 7	8	4	6	5	5	4
							9	77	9	10	8 – 9	9	4½	...	...	6	...
							10	88	10	11 – 12	10	10	...	7	6	...	...
							11	99									
							11 to 12	111									

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[4] *Repertorium für Meteorologie*, vol. iv. p. 2.

TABLE XVII.—Conversion of Factor 3 Velocities into corresponding Velocities using Factor 2·2.

3·0	2·2	3·0	2·2	3·0	2·2	3·0	2·2	3·0	2·2
1	0·7	21	15	41	30	61	45	81	59
2	1·5	22	16	42	31	62	45	82	60
3	2	23	17	43	32	63	46	83	61
4	3	24	18	44	32	64	47	84	62
5	4	25	18	45	33	65	48	85	62
6	4	26	19	46	34	66	48	86	63
7	5	27	20	47	34	67	49	87	64
8	6	28	21	48	35	68	50	88	65
9	7	29	21	49	36	69	51	89	65
10	7	30	22	50	37	70	51	90	66
11	8	31	23	51	37	71	52	91	67
12	9	32	23	52	38	72	53	92	68
13	10	33	24	53	39	73	54	93	68
14	10	34	25	54	40	74	54	94	69
15	11	35	26	55	40	75	55	95	70
16	12	36	26	56	41	76	56	96	70
17	13	37	27	57	42	77	56	97	71
18	13	38	28	58	43	78	57	98	72
19	14	39	29	59	43	79	58	99	73
20	15	40	29	60	44	80	59	100	73

TABLE XVIII.—Conversion of Miles per hour into Feet per second and Metres per second.

Miles per hour.	Feet per sec.	Metres per sec.	Miles per hour.	Feet per sec.	Metres per sec.	Miles per hour.	Feet per sec.	Metres per sec.	Miles per hour.	Feet per sec.	Metres per sec.
1	1·47	0·45	26	38·13	11·62	51	74·80	22·80	76	111·46	33·97
2	2·93	0·89	27	39·60	12·07	52	76·26	23·25	77	112·93	34·42
3	4·40	1·34	28	41·06	12·52	53	77·73	23·69	78	114·39	34·87
4	5·87	1·79	29	42·53	12·96	54	79·20	24·14	79	115·86	35·32
5	7·33	2·24	30	44·00	13·41	55	80·66	24·59	80	117·33	35·76
6	8·80	2·68	31	45·46	13·86	56	82·13	25·03	81	118·79	36·21
7	10·27	3·13	32	46·93	14·31	57	83·60	25·48	82	120·26	36·66
8	11·73	3·58	33	48·40	14·75	58	85·06	25·93	83	121·73	37·10
9	13·20	4·02	34	49·86	15·20	59	86·53	26·37	84	123·19	37·55
10	14·67	4·47	35	51·33	15·65	60	88·00	26·82	85	124·66	38·00
11	16·13	4·92	36	52·80	16·09	61	89·46	27·27	86	126·13	38·44
12	17·60	5·36	37	54·26	16·54	62	90·93	27·72	87	127·59	38·89
13	19·07	5·81	38	55·73	16·99	63	92·40	28·16	88	129·06	39·34
14	20·53	6·26	39	57·19	17·43	64	93·86	28·61	89	130·53	39·79
15	22·00	6·71	40	58·66	17·88	65	95·33	29·06	90	131·99	40·23
16	23·47	7·15	41	60·13	18·33	66	96·80	29·50	91	133·46	40·68
17	24·93	7·60	42	61·60	18·78	67	98·26	29·95	92	134·93	41·13
18	26·40	8·05	43	63·06	19·22	68	99·73	30·40	93	136·39	41·57
19	27·87	8·49	44	64·53	19·67	69	101·20	30·85	94	137·86	42·02
20	29·33	8·94	45	66·00	20·12	70	102·66	31·29	95	139·33	42·47
21	30·80	9·39	46	67·46	20·56	71	104·13	31·74	96	140·79	42·92
22	32·27	9·83	47	68·93	21·01	72	105·60	32·19	97	142·26	43·36
23	33·73	10·28	48	70·40	21·46	73	107·06	32·63	98	143·73	43·81
24	35·20	10·73	49	71·86	21·90	74	108·53	33·08	99	145·19	44·26
25	36·67	11·18	50	73·33	22·35	75	110·00	33·53	100	146·67	44·70

DISCUSSION.

The President (Mr. E. Mawley) said a hearty vote of thanks was due to Mr. Curtis for his admirable paper, as they must all recognise in it a piece of honest and sterling work, no pains having been spared to render it as complete and satisfactory throughout as the nature of the enquiry would allow. Indeed, few of the Fellows present would, he thought, be disposed to undertake an investigation involving, as this had done, the careful examination and discussion of over 22,000 observations. All meteorologists might not agree as to the accuracy of the conclusions at which the author had arrived, but for his own part he considered they would have to wait many years before closer approximations to the true velocity equivalents for wind-forces estimated by the Beaufort scale were available. The alteration of the original factor 3 to 2·2 for a standard Robinson anemometer created quite a revolution in our ideas as to high winds. For instance, taking the values given in Table XII. as correct, the velocity equivalent for a hurricane was, at one stroke of the pen, as it were, reduced from 105 to 77 miles an hour, that for a storm from 87 to 64 miles, for a whole gale from 72 to 53 miles an hour, and so on throughout the latter half of the scale.

Mr. W. H. Dines said they could not be too much indebted to Mr. Curtis for the time and trouble it must have taken to deal with such a large number of observations. He noticed that he had given 2 miles per hour as the equivalent of force 0. Since Mr. Curtis was simply dealing with the instrumental, compared with the estimated force, and was not suggesting what would be a suitable scale, this could not be avoided; but in any case he (Mr. Dines) thought it was quite justifiable, since a wind of under 3 miles per hour was hardly perceptible to the senses. He fully agreed with Mr. Curtis in his remark about the present practice of printing the returns. While the factor was doubtful, although the value 3 was known to be wrong, there was good ground for retaining it; but even then the process of printing records without comment, which everybody concerned knew to be wrong, was, to say the least, very curious. Now there seemed no excuse, as there would be no difficulty, in giving for each station nearly correct values; and if it were stated for a few years that a change had been made, and details of the change given, there need be no muddle or uncertainty. Anyway, nothing could be worse than the present practice of printing the Scilly and Holyhead records as though they were obtained from identical instruments, whereas to make them comparable at least 30 per cent must be added to the Scilly figures.

Mr. C. Harding said he believed that the Meteorological Office had not thought it wise, as yet, to make or advise, any change in the factor, as the subject had been in such an uncertain and unsatisfactory condition; and possibly we had not yet arrived at a final decision. He emphasized the desirability of making sooner or later the change once for all; and he said that if the change were made now it was possible that the general meteorological public of the future would be in doubt as to when the actual change was made. He thought it better to wait till, say, the year 1900, by which time there was a prospect of the question being finally settled with something approaching accuracy, and the period of change could be easily remembered. He did not like 0 of the Beaufort notation having any other equivalent than 0 in miles per hour, but that was of little importance. He was of opinion that the Beaufort notation, based on the original data of Beaufort's ship, did not now exist, and that we were now forming a universal wind scale for general use on land and at sea. He suggested that the equivalent velocities for the Beaufort units should not be the actual run of the wind in an hour, but expressed "at the rate of" so many miles an hour, as the actual observation is required distinctly at the time and not for any definite interval. He (Mr. Harding) submitted a scale, the equivalent velocities of which, once understood, could be easily remembered. In the scale which he suggested the summation of the Beaufort units with the digit 2 added gives the equivalent velocity:—

Formula: Beaufort units + 2 = rate of wind velocity in miles per hour.

The following comparison of the equivalents given in the present paper and his own figures showed very little difference:—

Beaufort Scale.

	0	1	2	3	4	5	6	7	8	9	10	11	12
Mr. C. Harding's equivalents .	0	3	5	8	12	17	23	30	38	47	57	68	80
Mr. Curtis's equivalents . .	2	4	7	10	14	19	25	31	37	44	53	64	77
Tube anemometer equivalents by Scilly 10 min. values	0	3	6	9	14	19	25	31	39	45	55	67	...

It was noticeable with Mr. Curtis's figures that there was no regular progression between the units. In the case of his (Mr. Harding's) suggestion the progression was regular—the increase for each unit being the unit itself—whereas the equivalent for 7 is 30 miles, that for 8 would be 38, for 9 it would be 47, etc.

Mr. G. J. SYMONS had been looking at the equivalent velocities given in various works, and had found great differences both for light and strong winds. For instance, with force 12 of the Beaufort scale, Mr. Curtis gave as the equivalent velocity 77 miles per hour. Mr. Omond, of Ben Nevis Observatory, gave 110 miles, while the tables published in the *Nautical Magazine* and in Laughton's *Physical Geography* gave 114 and 120 miles per hour respectively. With lighter winds also, great differences existed; thus for the equivalent of force 8 in Beaufort scale, the French *Meteorological Instructions* gave 30, Mr. Curtis 37, a table by Mr. Stow 43, Laughton's *Physical Geography* 50, Sir Henry James's *Instructions* 56, and the *Ben Nevis Report* 67 miles per hour. It was possible that the difference of factor accounted for part of the discrepancy, but it was certainly a very unsatisfactory condition of things. He was rather surprised at the remark as to the absence of estimated observations of wind force in the neighbourhood of the Orkneys, for comparison with the indications of the anemometer there; his impression was that fairly comparable values could be obtained from the Gremsay Low (West) Lighthouse.

Mr. F. GASTER said that if one thing could, more than another, justify the attempt made by Mr. Curtis to obtain some reliable values in wind velocity for the different points on Admiral Beaufort's scale as at present used at our coast stations, it was the statements just quoted by Mr. Symons. Not, indeed, that the figures mentioned by Mr. Symons represented anything like the extremes which had been put forward, for he had known an observer writing to the *Times* say that the force of a certain gale was so great that he had recorded a velocity of 14 (or 18) miles an hour!! in his garden. He pointed out, moreover, that the Beaufort scale by no means covers the extreme possible wind force, as it limits the meaning of force 12 (a hurricane) as "that which no canvas will withstand." The Indian and Mauritius hurricanes not only rendered "canvas" impossible, but blew with a velocity altogether outside anything of which we have any conception in this country. We hear of large guns pointing out of a fortress being blown completely over, backwards, by the force of the wind on their muzzles only; of large baulks of timber being carried bodily over walls, and so on—which indicates winds of a force untouched by the Beaufort scale; and there can be no doubt that many of the scales of velocity published by earlier meteorologists were largely conjectural, and pretended to include the "hurricane" velocities of the Indian cyclones. Until recent years the scales published were simply so much nonsense. Mr. Curtis's scale appeared to be by far the best hitherto proposed, and would probably hold its own for a long while to come. He would suggest that in the first part of the paper some note should be made referring the readers to the latter part, where reasons are given for believing the indications of Mr. Dines's anemometer to be really correct, but without which the statement in the earlier parts might read like a tacit assumption. A table for converting velocities obtained by using factor 3 into those obtained by using factor 2·2 would be also desirable, for we must remember that years and years of the former values have been published, and are not likely to be republished for factor 2·2.

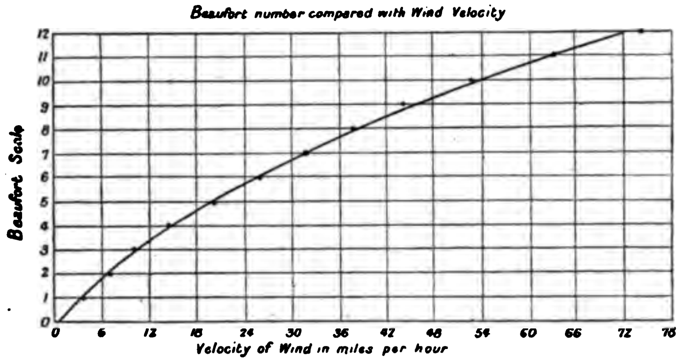
Mr. H. S. Wallis said that Mr. Curtis had thoroughly proved the *present* equivalents of the Beaufort scale, but he was doubtful whether they were the same when the scale was invented by Admiral Beaufort. In one of the earliest determinations of the equivalents—that given in Sir Henry James's *Instructions*—there was an equal increment of velocity for each increase of force, whereas the values given in the paper showed a rapidly increasing increment.

Mr. F. J. Brodie said that from certain remarks which appeared in the paper, it was quite clear that the estimation of wind-force by Beaufort scale was a matter in which personal bias played a very large part. At Yarmouth the observer was said to over-estimate the winds throughout the entire scale; while at Holyhead the force of strong winds was exaggerated, the lighter breezes being on the other hand rather under-estimated. At Scilly the estimations were, in the author's opinion, very near the mark, but assuming this to be the case, it must be remembered that the present observer was no longer young, and that in the course of a few years he might be replaced by a man who would give a very different account of the wind. He (Mr. Brodie) trusted they might live to see the day when so imperfect a system was amended by the adoption at all important stations of some cheap and simple form of anemometer, so that the wind-forces in different places might be more fairly comparable. He would be glad to know whether, in Mr. Curtis's opinion, the requisite conditions were fulfilled by the portable instrument lately invented by Mr. Dines.

Mr. W. Ellis desired to speak only of the numbers of Tables XI. and XII. In Table XI. it is seen that the observed values of wind velocity, corresponding to the numbers of the Beaufort scale, progress in a very satisfactory manner, considering that they are the equivalents of estimated forces of wind. For although the progression is a little retarded between the velocities of 14·5 miles and 37·3 miles, corresponding to the numbers from 4 to 8 of the Beaufort scale, it is yet on the whole of such a character as to render it probable that the existing little irregularity may be of the nature of accidental error, which an increased number of observations, as the higher part of the Beaufort scale is approached, might remove. The case appeared to be one in which treatment of the results as a whole might tend to produce a better general result. Such treatment he had endeavoured to apply as follows. Taking the observed velocities of wind of Table XI. (the mean values) to have equal weight, and calling V the velocity in miles per hour, and B the Beaufort number, twelve equations were constructed of the form $a + b.\mathrm{B} + c.\mathrm{B}^2 = \mathrm{V}$, in which a, b, and c are constants to be determined. These equations being by suitable combination reduced to three and solved, gave, as a probably sufficiently approximate solution, $1{\cdot}2 + 2{\cdot}08.\mathrm{B} + 0{\cdot}319.\mathrm{B}^2 = \mathrm{V}$. From this, values of velocity for the different numbers of the Beaufort scale were calculated as follows:—

		Beaufort Number.												
		0	1	2	3	4	5	6	7	8	9	10	11	12
Hourly velocity.	by formula	1·2	3·6	6·6	10·3	14·6	19·6	25·2	31·4	38·3	45·8	53·9	62·7	72·1
	as observed	...	3·9	6·9	10·0	14·5	20·0	25·6	31·4	37·3	43·9	53·1	63·3	74·1
	residual	...	+0·3	+0·3	−0·3	−0·1	+0·4	+0·4	0·0	−1·0	−1·9	−0·8	+0·6	+2·0

The circumstances will be better seen in the accompanying diagram, in which the curve represents the calculated values, and the dots the observed values.



Comparing now the calculated velocities to the nearest mile with those adopted by Mr. Curtis :—

	Beaufort Number.												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Calculated velocity	1	4	7	10	15	20	25	31	38	46	54	63	72
Adopted by Mr. Curtis	2	4	7	10	14	19	25	31	37	44	53	64	77
Variation of latter	+1	0	0	0	−1	−1	0	0	−1	−2	−1	+1	+5

The irregularity is thus greatest for the extreme high winds, as might be expected from the paucity of observations in that part of the scale. But at the lower end of the scale, at which observations are sufficiently numerous, the formula gives for $B = 0$, not a velocity of 0, but one of 1·2 miles (the constant of the formula), which seems to indicate that the lower B numbers are probably a little under-estimated, that is to say 3·9 miles, the observed equivalent velocity to $B = 1$, may be, more exactly, the equivalent to $B = 1\frac{1}{3}$. In fact, solving the equations before employed with omission of the term a, that is assuming $B = 0$ to correspond to $V = 0$, the expression found was $2{\cdot}51.B + 0{\cdot}289.B^2 = V$, which gives for the lower Beaufort numbers 0, 1, 2, 3, the velocities of 0·0, 2·8, 6·2, 10·1 miles respectively, the values found by the first formula being greater by 1·2, 0·8, 0·4, 0·2 miles respectively, indicating that the equivalent velocities of the B numbers for the lighter winds are relatively too large, that is, that the B numbers at this part of the scale are under-estimated. It might render the scale more natural, when there seems to be doubt as to which B number should be recorded, as for instance whether 0 or 1, or whether 1 or 2, if observers would, in such cases, prefer the higher of the two B numbers.

Capt. A. Carpenter said that, as a nautical man, he should like to make a few remarks on the use at sea of Admiral Beaufort's scale. Created as it was some 90 years ago, and based both on the speed and sail-carrying power of a well-found frigate of those days, its basis is now quite obsolete. Even in his early days, which were spent in men-of-war chiefly under sail, they never based

TABLE XIV.—Scale of Wind-Force—*Continued.*

Scale of Wind-Force.	[24] Waldo, 1887.						[25] Scotch Log-Book.			[26] Krümmel, 1892.		
	Miles per hour.											
	Scott's data reduced by Köppen.	Sprung's results given by Köppen.	Köppen's formula, from Cols. 2 and 3.	Waldo's results. Mean of three anemometers on board ship.	Waldo's results, using anemometer on wheel-house only.	Scott's results reduced by same formula as Sprung's and Waldo's.	Force.	Description.	Sail that can be carried.	Force.	Miles per hour.	Metres per second.
0	4·70	4·25	3·71	...	...	...	0	Calm . . .	All square sails and studding sails set.	0	...	...
1	6·49	6·04	6·30	7·83	7·83	8·72	1	Light airs . .	All plain sail set.	1	...	...
2	9·40	8·95	9·13	11·86	10·29	12·53	2	Light breeze .	Courses, topsails and topgallant sails set.	2	7·6	3·4
3	11·86	12·08	12·15	14·32	12·53	16·55	3	Smart breeze .	Single reefs and topgallant sails over.	3	11·4	5·1
4	15·44	15·21	15·34	16·55	15·88	20·58	4	Fresh breeze .	Single reefs and topgallant sails in.	4	15·9	7·1
5	19·46	18·34	18·77	19·91	20·58	24·61	5	Strong breeze .	Double reefs in. Jib and spanker set.	5	21·0	9·4
6	23·94	21·92	22·37	26·17	27·74	29·08	6	Moderate gale .	Double reefs. Jib and spanker in.	6	26·2	11·7
7	28·41	23·94	26·17	30·20	34·23	34·67	7	Fresh gale . .	Double reef topsails and reefed courses.	7	31·8	14·2
8	32·44	27·74	30·20	35·79	36·69	40·94	8	Strong gale . .	Close-reefed and courses in.	8	36·2	16·2
9	35·12	33·33	34·41	42·28	39·82	47·42	9	Whole gale . .	Hove to.			
10	...	...	...	...	...	...	10	Storm or Hurricane	No sail set.			
11	...	...	...	...	...	...						
12	...	...	...	...	...	...						

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[24] *American Meteorological Journal*, vol. iv. p. 274.

[25] This scale is printed on the cover of many log-books used by large steamships sailing out of Scotch ports. (Wm. Allingham, *The Nautical Magazine*, March 1896.)

[26] *Plankton-Expedition der Humboldt-Stiftung*, Band I., Sec. C., von Dr. Otto Krümmel, 1892.

ARRANGED IN ORDER OF DATE OF PUBLICATION.

[1] KAEMTZ, 1845.

Force.	Description of Wind.
0	Gentle wind (slight breeze).
1	Moderate wind (brisk breeze).
2	Strong wind (fresh breeze.)
3	Violent wind (strong gale).
4	Storm and tempest.

[2] THOMSON, 1849.

Velocity, miles per hour.	Description of Wind.
1	Hardly felt.
2 3	Light breeze, barely perceptible.
4 5	Gentle breeze.
10 15	Brisk, pleasant, gale.
20 25	Very brisk gale,—*fresh*.
30 35	High wind or strong gale.
40 45	Very high wind or hard gale.
50 60	Hurricane, tempest.
80 100	Violent hurricane, tearing up trees, overturning buildings, etc.

[3] DREW, 1855.

Pressure, lbs. per square foot.	Description of Wind.
0	Calm.
0·26	Pleasant wind.
0·52	Fresh breeze.
2·6	Brisk gale.
5·21	High wind.
10·42	Very high wind.
15·62	Storm.
20·83	Great storm.
26·04	Very great storm.
31·75	Hurricane.

[4] SCHOTT, 1861.

Pressure, lbs. per square foot.	Velocity, miles per hr.	Description of Wind.
0·000	0	Calm.
0·005	1	Light air.
0·08	4	Gentle breeze.
0·9	13	Moderate breeze.
2·6	23	Fresh breeze.
5·1	32	Strong breeze.
7·9	40	Fresh gale.
12·0	50	Strong gale.
18·0	60	Storm.
31·0	80	Tempest.
49·0	100	Hurricane.

[5] HERSCHEL, 1862.

Velocity, miles per hour.	Description of Wind.
7	Gentle air.
14	Light breeze.
21	Good sailing breeze.
41	Gale.
61	Great storm.
82	Tempest.
92	Hurricane.

[6] GLAISHER, 1863?

Force.	Description of Wind.	Beaufort Equivalents.
1	Moderate .	1 – 2
2	Fresh . .	3 – 4
3	Strong . .	5 – 6
4	Heavy . .	7 – 8
5	Violent . .	9 – 10
6	Tremendous .	11 – 12

[7] GLAISHER, 1863.

Estimated Force.	Description of Wind.
0.0	Calm.
0.1 0.2	Very light airs.
0.3 0.4 0.5	Light breeze.
0.6 0.7 0.8	Moderate breeze.
0.9 1.0 1.1	Fresh breeze.
1.5 2.0 2.5	Very fresh wind.
3.0 3.5	Strong wind, gale.
4.0	Strong gale.
5.0	Heavy gale.
6.0	Hurricane.

[8] FITZROY, 1863.

Sea Scale.	Character of Wind.	Land Scale.	Velocity, miles per hour.
1 to 3	Light . . .	0 to 1	10
3 – 5	Moderate . .	1 – 2	25
5 – 7	Fresh . .	2 – 3	40
7 – 8	Strong . .	3 – 4	55
8 – 10	Heavy . .	4 – 5	70
10 – 12	Violent . .	5 – 6	85

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[1] Kaemtz's *Meteorology*, translated by C. V. Walker, p. 29 (1845).

[2] *Introduction to Meteorology*, by D. P. Thomson, M.D., p. 378.

[3] *Practical Meteorology*, by John Drew, Ph.D., F.R.A.S., p. 113. This scale is based on results from Lind's Wind-gauge.

[4] Discussion of Sir F. M'Clintock's observations on board the *Fox*. *Smithsonian Contributions*, vol. xiii. No. 146, p. 39. This table was used to obtain the equivalents for Beaufort's scale (see Table I.).

[5] Herschel's *Meteorology*, pp. 55-56.

[6] Taken from *Ocean Meteorology*, by Findlay, edited by W. R. Martin, R.N.

[7] *Weather Book*, p. 42.

[8] *The Weather Book*, p. 38.

TABLE XV.—SCALE OF WIND-FORCE—*Continued.*

[9] BUCHAN, 1867.			[10] BUCHAN, 1871.				[11] WILD, 1873.	
Estimated Force.	Velocity, miles per hour.	Description of Wind.	Scale 0 to 6.	Velocity, miles per hour.	Beaufort Equivalents.	Description of Wind.	Usual designation of the Wind.	Velocity, miles per hour.
0·0	0·0	Calm.	0·0	0·0	0	Calm.	Very light breeze . .	2·2
0·1	1·4	Lightest breath of air.	0·5	7·1	1	Light air.	Light	4·4
0·5	7·1	Very light air.	1·0	14·1	2	Light breeze.	Gentle	6·7
1·0	14·1	Light air.	1·5	21·2	3	Gentle breeze.	Moderate . . .	9
1·5	21·2	Light breeze.	2·0	28·3	4	Moderate breeze.	Moderately fresh . .	11
2·0	28·3	Fresh breeze.	2·5	35·4	5	Fresh breeze.	Fresh	13
2·5	35·4		3·0	42·4	6	Strong breeze.	Very fresh . . .	16
3·0	42·4	Very fresh.	3·5	49·5	7	Moderate gale.	Moderately strong . .	18
3·5	49·5		4·0	56·6	8	Fresh gale.	Strong	20
4·0	56·6	Blowing hard.	4·5	63·6	9	Strong gale.	Very strong . . .	22
4·5	63·6		5·0	70·7	10	Whole gale.	Rather violent . .	27
5·0	70·7	Blowing a gale.	5·5	77·8	11	Storm.	Violent	31
5·5	77·8	Violent gale.	6·0	84·8	12	Hurricane.	Very violent . . .	36
6·0	84·8	Hurricane.					Moderate storm . .	40
							Storm	45
							Heavy storm . . .	51
							Moderate hurricane .	58
							Hurricane . . .	67
							Violent hurricane . .	79

[12] DICTIONARY, 1878.				[13] KINGSTON, 1878.			[14] FRENCH TELEGRAPHIC CODE, 1879.		[15] MASCART, 1883.		
Land Scale.	Description of Wind.	Beaufort Equivalents.	Velocity, feet per sec.	Force.	Description of Wind.	Approximate Velocity, miles per hour.	Force.	Description of Wind.	Force.	Description of Wind.	Approx. Veloc., Kilometres per hour.
0	Calm .	0 – 1	0·13	0	Calm or light air	Not exceeding 2	0	Calm.	0	Calm . .	0
1	Light .	1	14·7	1	Light air . .	Above 2 and not exceeding 4	1	Nearly calm.	1	Light . .	7
2	Moderate	2	36·7	2	Light breeze .	„ 4 „ 8	2	Very light.	2	Moderate .	25
3	Fresh .	3 – 4	58·7	3	Moderate breeze	„ 8 „ 16	3	Light.	3	Rather strong.	40
4	Strong .	5 – 6	80·7	4	Fresh breeze .	„ 16 „ 25	4	Moderate.	4	Strong . .	60
5	Heavy .	7 – 9	102·7	5	Strong breeze .	„ 25 „ 34	5	Rather strong.	5	Very strong .	75
6	Violent .	10 – 12	127·4	6	Moderate gale .	„ 34 „ 44	6	Strong.	6	Tempest .	100
				7	Fresh gale .	„ 44 „ 55	7	Very strong.	7	Hurricane .	160
				8	Strong gale .	„ 55 „ 67	8	Violent.			
				9	Heavy or whole gale	„ 67 „ 80	9	Tempest.			
				10	Hurricane .	„ 80 miles.					

for rain in snow. Is there any definite relation between the two? Scott says —*Elementary Meteorology*—"*On a very rough estimate*, a foot of snow yields about an inch of rain." It appears a simple matter to measure the depth of snow on the ground. But there are several disturbing factors. There are various kinds of snow: moist and crisp; flakes, large and small; so that layers of snow differ greatly in compactness. It is not a constant quantity. Then again, there is the difficulty of selecting a spot upon which a fair, even depth of snow, unaffected by drift or whirl, has fallen. And we can hardly accept the amount of snow caught in the rain-gauge as a trustworthy measure of the actual fall.

Taking all available precautions, I measured 2·25 inches of snow on January 17th, the result of 24 hours' fall. The snow caught in the gauge, melted, gave ·21 inch of rain. That is, nearly as $10\frac{5}{7}$ is to 1. This approximates to Mr. Scott's "*very rough estimate*," that is, 12 to 1. I also filled the Symons' rain-gauge funnel with light snow as it had fallen, and before it had become condensed by gravitation and liquefaction. This gave 1·10 inches. The gauge holds 5·50 inches of water. It is hardly probable that the gauge catches the full fall. A better snow-gauge would be a large shallow tank, say 6 feet square, standing, of course, in an open site.

There is another aspect of the subject which deserves attention. This is the hygrometric value of snowfall. A large proportion of the snowfall in this humid climate disappears slowly by melting in bright sunshine, thaw, or rains. A variable proportion is taken up by the air. The proportion, of course, depends upon the relative dryness and movement of the air. And here is where snow comes in as a test of humidity. In dry climates snow rapidly disappears. I took note of a snowfall at Valescure on the Riviera. It was an inch deep. In less than an hour after its fall it was all carried away by evaporation under a light breeze, leaving the ground it had fallen upon perfectly dry.

Hence the rapidity of evaporation of snow may serve as a measure of the humidity of the air, and thus as a valuable test of climate in its relation to health. This snow-evaporation test may at times be more valuable than the comparison of the dry and wet thermometers and the evaporation of water.—Robert Barnes, M.D., January 27, 1897.

[Instead of the "large shallow tank" recômmended by Dr. Barnes, it would be much better to use in snowy weather a cylinder of the same diameter as the rain-gauge, and of considerable depth, as with strong winds the snow would be whisked out of the "large shallow tank."—Editor.]

Waterspouts in the English Channel.—Mr. H. M. Lambert, F.R.Met.Soc., sends the following extract from the report of Capt. R. Sharp of the T.S.S. *Sussex* with reference to his voyage from Dieppe to Newhaven on October 13, 1896:—

"I beg to report that the T.S.S. *Sussex* left Dieppe at 1.48 p.m. to-day, wind North-east, blowing a gale, with heavy sea. At 4.10 p.m., when about 13 miles south of Beachy Head, observed a large black cloud coming up very fast from the north-east and low down on the water. As the distance between cloud and ship decreased I was surprised to observe that from it several waterspouts were pendant, and as they were right in our course, and I was uncertain of their effect upon a ship passing through them, I deemed it advisable to give them a clear berth. There were no less than ten distinct waterspouts travelling at a great speed, accompanied by a spiral action of the water. I passed close to windward of one of them, and distinctly observed masses of water resembling heavy spray ascending. As this is the first time I have observed this phenomenon in these latitudes, I have ventured to send you this report on the matter."

Waterspout at Kirkwall.—Mr. R. H. Scott, F.R.S., has forwarded the following note from the Meteorological Office observer at Kirkwall, Orkneys:—

"On September 19, 1896, about 11.30 a.m., a large trumpet-shaped cloud was observed near Holm Sound with its narrow end towards the ground. It was travelling in an easterly direction, and about five miles distant. It gradually veered round till, when it neared the land, one mile to east, the course was northerly. It now travelled towards the Ward Hill, the highest in this parish. The wind all the time was either a dead calm, or blowing first from one quarter and then another. Very little rain fell in its course near the sea, but when it reached ground about 100 feet above sea-level the rainfall was so heavy that no one had remembered anything so severe. The heaviest fall covered an area of not more than half a mile in length and about a quarter in breadth. More than an inch must have fallen in some places. The burns were so flooded that bridges could not give passage to the water. Some hail also fell."

Bird Migration in the British Isles.—At the meeting of the British Association held at Liverpool in September 1896, Mr. W. E. Clarke presented a digest of the observations on the migration of birds made at lighthouses and light-vessels during the period 1880-1887. The following is an abstract of his report on the meteorological aspect of the subject:—

When studying bird migration in connection with meteorological conditions, it is only necessary to consider the weather peculiarities prevailing in the area where the movement has its origin. The weather prevailing upon the shores reached after an extended flight does not affect the movement. An extensive series of comparisons instituted between the records of migration and the *Daily Weather Reports* of the Meteorological Office, shows an intimate connection between weather and bird migrations. During the spells of genial weather that occur in both the spring and autumn periods of migration, the movements are of an even and continuous nature. If the weather at such times becomes slightly unsettled, it is a matter of indifference to the migrants; but if it becomes more markedly variable, their movements are somewhat quickened.

Certain weather conditions, however, have a very decided influence in either hindering or promoting migration. Unfavourable conditions of a pronounced nature may render migration impossible; while, on the other hand, favourable weather following unfavourable periods may tempt birds to start on their way. A decided fall of temperature warns them to move southwards, and such cold spells are characteristic of anticyclonic periods, when the weather is calm and highly favourable for a prolonged flight. The most important factor is temperature, and it regulates migration, other meteorological conditions being favourable.

From the end of September to early in November the autumn migrations into our islands from the north-east are sufficiently pronounced to be associated with weather changes. In ordinary seasons the period named is characterised by a series of great immigratory movements simultaneously performed, not only by many species, but also by a vast number of individuals. It has been ascertained that all these great movements are due to the prevalence of weather conditions favourable for migration in North-western Europe. These conditions are the result of the following type of pressure distribution—namely, the presence of a large and well-defined anticyclone over the Scandinavian Peninsula, with gentle gradients extending in a south-westerly direction over the North Sea. On the other hand, cyclonic conditions prevail to the westward of the British area, with a low pressure centre off the west coast of Ireland, or occasionally farther south. Consequently the weather is clear and cold, with light variable winds over Norway and Sweden; while in Britain the sky is overcast, and moderate to strong Easterly winds are experienced. Previously to this period cyclonic conditions usually prevail in Scandinavia, which check migration, and at the same time warn the birds that it is time to depart. The

TABLE XVII.—CONVERSION OF FACTOR 3 VELOCITIES INTO CORRESPONDING VELOCITIES USING FACTOR 2·2.

3·0	2·2	3·0	2·2	3·0	2·2	3·0	2·2	3·0	2·2
1	0·7	21	15	41	30	61	45	81	59
2	1·5	22	16	42	31	62	45	82	60
3	2	23	17	43	32	63	46	83	61
4	3	24	18	44	32	64	47	84	62
5	4	25	18	45	33	65	48	85	62
6	4	26	19	46	34	66	48	86	63
7	5	27	20	47	34	67	49	87	64
8	6	28	21	48	35	68	50	88	65
9	7	29	21	49	36	69	51	89	65
10	7	**30**	22	**50**	37	**70**	51	**90**	66
11	8	31	23	51	37	71	52	91	67
12	9	32	23	52	38	72	53	92	68
13	10	33	24	53	39	73	54	93	68
14	10	34	25	54	40	74	54	94	69
15	11	35	26	55	40	75	55	95	70
16	12	36	26	56	41	76	56	96	70
17	13	37	27	57	42	77	56	97	71
18	13	38	28	58	43	78	57	98	72
19	14	39	29	59	43	79	58	99	73
20	15	**40**	29	**60**	44	**80**	59	**100**	73

TABLE XVIII.—CONVERSION OF MILES PER HOUR INTO FEET PER SECOND AND METRES PER SECOND.

Miles per hour.	Feet per sec.	Metres per sec.	Miles per hour.	Feet per sec.	Metres per sec.	Miles per hour.	Feet per sec.	Metres per sec.	Miles per hour.	Feet per sec.	Metres per sec.
1	1·47	0·45	26	38·13	11·62	51	74·80	22·80	76	111·46	33·97
2	2·93	0·89	27	39·60	12·07	52	76·26	23·25	77	112·93	34·42
3	4·40	1·34	28	41·06	12·52	53	77·73	23·69	78	114·39	34·87
4	5·87	1·79	29	42·53	12·96	54	79·20	24·14	79	115·86	35·32
5	7·33	2·24	**30**	44·00	13·41	55	80·66	24·59	**80**	117·33	35·76
6	8·80	2·68	31	45·46	13·86	56	82·13	25·03	81	118·79	36·21
7	10·27	3·13	32	46·93	14·31	57	83·60	25·48	82	120·26	36·66
8	11·73	3·58	33	48·40	14·75	58	85·06	25·93	83	121·73	37·10
9	13·20	4·02	34	49·86	15·20	59	86·53	26·37	84	123·19	37·55
10	14·67	4·47	35	51·33	15·65	**60**	88·00	26·82	85	124·66	38·00
11	16·13	4·92	36	52·80	16·09	61	89·46	27·27	86	126·13	38·44
12	17·60	5·36	37	54·26	16·54	62	90·93	27·72	87	127·59	38·89
13	19·07	5·81	38	55·73	16·99	63	92·40	28·16	88	129·06	39·34
14	20·53	6·26	39	57·19	17·43	64	93·86	28·61	89	130·53	39·79
15	22·00	6·71	**40**	58·66	17·88	65	95·33	29·06	**90**	131·99	40·23
16	23·47	7·15	41	60·13	18·33	66	96·80	29·50	91	133·46	40·68
17	24·93	7·60	42	61·60	18·78	67	98·26	29·95	92	134·93	41·13
18	26·40	8·05	43	63·06	19·22	68	99·73	30·40	93	136·39	41·57
19	27·87	8·49	44	64·53	19·67	69	101·20	30·85	94	137·86	42·02
20	29·33	8·94	45	66·00	20·12	**70**	102·66	31·29	95	139·33	42·47
21	30·80	9·39	46	67·46	20·56	71	104·13	31·74	96	140·79	42·92
22	32·27	9·83	47	68·93	21·01	72	105·60	32·19	97	142·26	43·36
23	33·73	10·28	48	70·40	21·46	73	107·06	32·63	98	143·73	43·81
24	35·20	10·73	49	71·86	21·90	74	108·53	33·08	99	145·19	44·26
25	36·67	11·18	**50**	73·33	22·35	75	110·00	33·53	**100**	146·67	44·70

"Report on the Hay Harvest Forecasts" to the University Extension College at Reading (published in *Report of the Meteorological Council*, 1895). The last instalment of the *Forschungen zur deutschen Landes- und Volkskunde* consists of a paper by Dr. Paul Moldenhauer, of Kiel, on the distribution of rainfall in North-Western Germany, and is a model of careful statistical research. Dr. Moldenhauer confirms the general features of the distribution worked out by former investigators, and the more abundant material at his disposal enables him to add some conclusions of a general nature which we should like to see extended to this country. Of the two factors usually considered as modifying rainfall—distance from the sea and elevation above it—the latter is relegated to a less important position, and made to yield to a third, viz. exposure with respect to the rain-bearing winds. The favourable or unfavourable conditions of exposure can evidently not be expressed numerically: Dr. Moldenhauer contents himself with a division under a number of heads; distance from the source whence the rain-bearing winds derive their moisture; amount of shelter received from mountains, not greatest immediately on their lee side, but at some distance; position of mountains to leeward, the rainfall being sensibly increased even some distance away on the weather side of a range; position of the station itself on a slope, the rainfall being greater on a weather than on a lee slope *at the same elevation*. The increased rainfall on the weather side of a small range may extend for some distance on the lee side, but if the summit is a plateau the rainfall gradually decreases from the weather side leewards. The conditions may be summed up in the statement that places at the same elevation receive more rain the more freely they are exposed to the rain-bearing winds, a result not nearly so much of a truism as it looks. By comparing stations at equal elevations only is it possible to get rid of the effect of altitude, and obtain a comparative view of "freedom of exposure." Dr. Moldenhauer finds, for the area with which his paper deals, that the west and north sides of the Rhine hills north of the Moselle and Lahn are the "most exposed," then come in order the Teutoburger Wald, the Harz, the Hundsruck, Spessart, Vogelsberg, the rest of the Rhine hill country and the Solling, and finally the Thüringer Wald and the Rhön-gebirge. A paper by Herr Otto Rubel, in the *Geographische Abhandlungen aus den Reichslanden Elsass-Löthringen*, on the rainfall of Upper Alsace, forms along with Dr. Moldenhauer's an important contribution to our knowledge of the climatology of Western Germany. Herr Rubel is not, of course, in a position to make generalisations extending beyond the restricted area which he makes his special study, but he elucidates some points of interest with regard to the seasonable distribution of the rainfall in Alsace-Lorraine. On the lower plains summer is the wettest season of the year, and winter the driest, while the hill stations show most rainfall in autumn and least in spring, and the intermediate stations indicate a gradual transition from the one type to the other. Snow is most frequent in Upper Alsace in December, with, however, a secondary maximum in March. Thunderstorms occur oftenest in June, and they are rare in winter.—*Geographical Journal.*

Wind Records at Kingston, Jamaica.—Mr. J. F. Brennan has recently published a discussion of the records obtained from the anemometers at Kingston, Jamaica. In nearly all the months, except May and September, there is a decided diminution in the velocity about the time of sunrise. This appears to be due to the gradual cessation of the land breeze, just before the temperature begins to rise and till when the sea breeze sets in. The sea breeze, which is South-easterly for Kingston, would appear to commence as a light wind (in most cases starting Westerly and South-westerly) at about the following hours:—

January .	8 a.m.	May . .	7 a.m.	September	7 a.m.
February .	7 ,,	June . .	5 ,,	October .	7 ,,
March	7.30 ,,	July . .	7 ,,	November	8 ,,
April . .	7 ,,	August	7.30 ,,	December	8.30 ,,

Starting from a minimum rate of about two miles the wind increases until it attains its maximum about mid-day. The time when the minimum occurs appears to be governed by the time of sunrise. During the night when the land breeze blows there is much irregularity of pressure. The mean maximum velocity of the sea breeze is about four times as great as that of the land breeze.

RECENT PUBLICATIONS.

Journal and Proceedings of the Royal Society of New South Wales. Vol. XXIX. 1895. 8vo.

Contains the following meteorological papers:—Icebergs in the Southern Ocean: by H. C. Russell, F.R.S. (30 pp.).—Notes on the rainfall of the Southern Riverina, 1872-94: by H. C. Kiddle (7 pp.). The district termed the Southern Riverina embraces all the area between the Murray and Murrumbidgee rivers, and extends as far east as the meridian of 147° 30′ E.—The Climate of Lord Howe Island: by H. C. Russell, F.R.S. (1 p.). Lord Howe Island possesses a mild climate, which Mr. Russell points out is due to the surrounding currents of tropical water coming down from the north.—Types of Australian Weather: by H. A. Hunt (39 pp.).

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. October and November 1896. 4to.

The principal articles are:—Telemeteorographie: von M. Snellen (11 pp.). This is a reproduction of a paper which Dr. Snellen printed in the Report of the Upsala meeting of the International Meteorological Committee.—Die Bestimmung des Wasserdampfgehaltes der Atmosphäre auf Grund spektroskoptischer Messungen: von T. Arendt (15 pp.). The author claims to have obtained a standard spectral scale to which the lines shown in a spectrum can always be referred. If this is really well established the result will be very useful, for in all previous accounts of rain-band work in these islands no sort of scale was ever suggested. Dr. Arendt's work was carried on with the large spectroscope of the Potsdam Observatory.—Temperatur und Hydrometeore auf dem Augustia Peak in Sudindien und am Fusse des Berges: von A. Woeikof (12 pp.). This is a review of Mr. J. Eliot's publication of the observations of the late John Allan Broun, F.R.S. It may perhaps be known that the volumes of observations were handed over by Mrs. Broun to the Meteorological Office for safe keeping. After the lapse of many years the Indian authorities applied for them, and they are now being published in the *Indian Meteorological Memoirs.* Dr. Woeikof points out that Augustia Peak is not a mountain station in the same sense as several of those in Europe; and, moreover, that at the foot of the mountain the damp plains do not exhibit such a diurnal range of temperature as in the Alpine valleys. The relative humidity on the Peak is excessive, the annual mean being 96 per cent. The driest month has 83 per cent, and only two months' fall below 90 per cent. Dr. Woeikof, however, points out that very sudden and extensive changes in humidity occur, and great dryness appears with anticylonic conditions in winter.—Winde und Temperatur auf dem Pike's Peak: von A. Woeikof (4 pp.). This is a discussion of the observations for part of 1892 and the whole of 1893 at the new Peak Observatory, and at Colorado Springs, with a difference of level of about 7000 feet. The extreme forces of the wind above are not nearly so high as at Mount Washington. The decrease of temperature with height is the greatest as yet noticed.

Symons's Monthly Meteorological Magazine. October—December 1896. 8vo.

The principal articles are:—The rainfall of September 1896 (4 pp.). Over a large area in the South of England, extending from Kent to Somerset, about 2½ times the normal amount of rain fell; while over almost the whole of the United Kingdom, south of latitude 52°, more than twice the average was recorded, the exceptions being Cornwall and Mid-Gloucester. In Durham and Northumberland the fall was only slightly in excess. In the Fen country the fall was not exceptional, but over the whole of the remainder of England it was fully 50 per cent in excess. Over Scotland generally the rainfall was about 1½ times the average; while in Ireland it was decidedly heavier than in Scotland.—The frost of February 1895 (2 pp.).—Whirlwinds, Cyclones, and Tornados: by R. de C. Ward (2 pp.).—The Climate of the British Empire in 1895 (2 pp.).—The scientific use of Kites (4 pp.).—Meteorological Observations in Schools: by R. de C. Ward (5 pp.).—Weather in the last century, 1713 to 1745 (5 pp.). This gives the summaries of the weather for each year, and also some occasional notes made by Mr. George Smith at Richmond, Surrey.—Barometri Descriptio (2 pp.). This is a reprint of a Latin poem by Joseph Addison.

Transactions of the Royal Society of Edinburgh. Vol. XXXVIII. 1896. 4to.

This contains:—The Meteorology of Edinburgh by R. C. Mossmann (75 pp.). In this paper the author deals with the mean values of the climatic element for each day of the year, as it is evident that many of the most interesting features of the pressure and other curves are wholly eliminated when monthly means alone are under consideration. The data for the instrumental observations have been calculated for the fifty years 1840-51 and 1857-94, while the non-instrumental observations embrace a period of 132 years.

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SHADE TEMPERATURE.

By EDWARD MAWLEY, F.R.H.S., PRESIDENT.

An Address delivered to the Royal Meteorological Society, January 20, 1897.

MR. SCOTT, in his *Elementary Meteorology*, remarks, with much truth, that "the determination of the temperature of the air is without doubt the most important of meteorological observations, for, as Dr. Angus Smith has pointed out in his work on *Air and Rain*, 'heat is a more pressing want than even pure air.'" Indeed, the first question invariably asked in regard to almost any climate is as to its temperature, whether the inquiry be made in the interests of health, agriculture, or trade, or even in those of pleasure, sport, or what not. It is therefore not surprising to find that ever since regular observations of the weather have been made, meteorologists should have expended much time and thought in their endeavours to solve this important question. In what way can the true temperature of the air be best ascertained? At first sight it may appear an easy matter to obtain air temperatures, but a little consideration will show that scarcely anything is more difficult, if the results are to be of any real or permanent value.

The sole source from which the air receives its heat is the sun. The air is not warmed directly by the passage of the sun's rays through it, but indirectly by contact with the heated surface of the earth. Were thermometer bulbs, like the atmosphere, uninfluenced by the direct or reflected rays of the sun, the observation of air temperatures would be comparatively easy, but unfortunately this is not the case. It therefore becomes necessary that some protection from direct solar influence be afforded to the instruments. Even when this is successfully accomplished there are two other sources of error to be guarded against, viz. direct radiation from the ground during the daytime, and radiation from the thermometer to the sky at night. Supposing these disturbing influences to have been satisfactorily provided against, there still remains the difficulty of doing this without unduly checking the flow of air to the bulbs, without shading the ground beneath them, and without allowing the very guards intended to keep off the sun from becoming so heated in hot weather as to cause the thermometers to read higher than they otherwise would do. When all the above conditions have been complied with, the shelter provided, to be of practical value, must be impervious to rain, be available in moderately confined as well as in fully exposed positions, and be, moreover, inexpensive and durable.

It may be therefore interesting if, in the first place, we glance in passing at some of the various methods that have been from time to time devised and recommended for general adoption.

Early Thermometer Exposure.

Going back to 1818, we find that Luke Howard, F.R.S., in his work on the *Climate of London*,[1] suggests the following plan. "A Six's thermometer," he says, "should be *mounted* (at about 5 feet from the ground) and screwed on a fixed support. . . . Or a mahogany frame may be provided with two projecting brackets, into which the box scale may enter by a pivot at each end. By this means the thermometer may be set facing that part of the general north exposure, where, from the disposition of the surrounding objects, the heat may have the freest *radiation to the open sky;* a point which late discoveries show to be important. . . . To the above mounting, it will in some situations be proper to add a small shelter *above* the instrument, which shall suffice to keep off the direct showers at least; and, at a suitable distance on the west side, a shade movable on hinges, to be interposed, in the heat of summer, between the instrument and the rays of the afternoon sun."

The arrangement proposed is a somewhat primitive one, but shows clearly, among other things, that the author, with his usual foresight, appreciated the necessity of an open situation for his thermometer stand.

About thirty years later J. H. Belville, Assistant at the Royal Observatory, Greenwich, in his *Manual of the Thermometer*, published in 1850, advocates an altogether different plan. He says (pp. 9-10) "the thermometer, as a meteorological instrument, requires much caution in the selection of a situation for it; it must be placed *absolutely* in the shade, and as far away as possible from the influence of heat *reflected* from walls and buildings." He advises "that a post be driven into the ground a few feet from the *north* wall of a house (or a stand), with a bracket and hood, against the back of which the thermometers may be fixed, and that the minimum should be so fixed that one side of it may be easily unhooked, to allow the index to return to the extremity of the fluid." It will thus be seen that, unlike Luke Howard, Belville recommends a north exposure in deep shade. That Belville should have done so is rather surprising, when we consider that about 1840, or about ten years before, Mr. Glaisher and the late Astronomer-Royal (Sir G. B. Airy) had devised a thermometer screen, afterwards known as the Greenwich or Glaisher stand, which was evidently intended to be set up in a fully exposed position.

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[1] *Climate of London*, by Luke Howard, F.R.S., 1833, vol. i. p. xiv.

Strathfield Turgiss Experiments.

By 1868 so many different thermometer screens were in use that at Mr. Symons's suggestion it was decided to carry out a series of comparisons to ascertain their respective merits. With this object in view he obtained from the Government Grant Committee of the Royal Society a sum of £45, and subsequently, from the Meteorological Council, a further sum of £25, to defray part of the cost of the experiments. The late Rev. C. H. Griffith kindly undertook the task, by no means a light one, of taking the readings of all the instruments at 9 a.m., 3 p.m., and 9 p.m. daily from November 1868 to April 1870, or for eighteen consecutive months. An admirable position for the various thermometer screens was found in a meadow adjoining Mr. Griffith's Rectory at Strathfield Turgiss in Hampshire. The screens tested may be divided into four classes :—(1) *Open Screens,* which were represented by the Pastorelli, the Lawson, the James, the Glaisher, and the Stow. (2) The *Intermediate Screens,* by the Martin and the Griffith. (3) *Closed Screens,* by the Stevenson and the Kew. (4) *Wall Screens,* by the Morris. There were also a suspended thermometer and an aspirated thermometer. So numerous were the observations that had been made at the end of the eighteen months, that no one appeared to have the courage to discuss them until it was undertaken by Mr. Gaster, who worked out the mean values for all the screens. The results for several of the typical screens were published as an appendix to the *Quarterly Weather Report* for 1879. The following are some of the conclusions at which he arrived :—

1. That in winter time, and especially in very cloudy (overcast) weather, when the sun's power is slight, and when terrestrial radiation is greatly checked, the indications of the stands agree very closely.

2. That as the sun's power increases, and during clear bright weather at night, considerable differences manifest themselves, the open screens (especially the Pastorelli and the Lawson) giving indications considerably in excess of the closed screens during the day, and in defect of them during the night.

Conditions for a Perfect Thermometer Screen.

In 1873, Mr. Symons collected opinions from all those British meteorologists who had made a special study of this question of thermometer exposure, as to the best method to be adopted. At the November meeting of this Society in the same year, he submitted a digest of these views to the Fellows. An animated discussion took place, and the following resolutions were agreed to as representing the conditions that must be fulfilled by a perfect thermometer screen :—

1. The contained thermometer must at all times be shielded from the direct rays of the sun.

2. The stand must be so arranged that even when its own external temperature is raised, the thermometers shall not be thereby materially affected.

3. As reflected heat must diminish the accuracy with which thermometers indicate air or shade temperature, these disturbing causes should be excluded.

4. The temperature of the air alone being required, it is desirable that the readings of the thermometer be protected from the communication of other exterior influences.

5. It is desirable that one pattern of stand be used in all localities.

6. It is desirable that the stand should be absolutely independent of all surrounding objects.

7. There must be free access of air round the thermometers.

8. No rain should ever reach the dry bulb thermometers, for if it does it improperly lowers their temperature, making them read even lower than the wet bulb.

9. The stand must also be unaffected by snow, whether a direct fall or by impeding access of air.

10. It is very desirable that the stand requires no alteration between the hours of observation.

11. It is desirable, but not absolutely necessary, that room be provided for a duplicate set of thermometers.

12. The stand should not be costly.

13. It should be portable by rail or otherwise.

Stevenson Screen.

The result of this discussion was that the Stevenson screen, as best fulfilling the above conditions, was recommended by the Society for general adoption in this country. The original Stevenson screen, a description of which will be found in vol. i. p. 122 of the *Journal of the Scottish Meteorological Society*, was designed by the late Thomas Stevenson, C.E., F.R.S.E. Its internal dimensions were as follows:—It was 14½ inches wide, 7½ inches

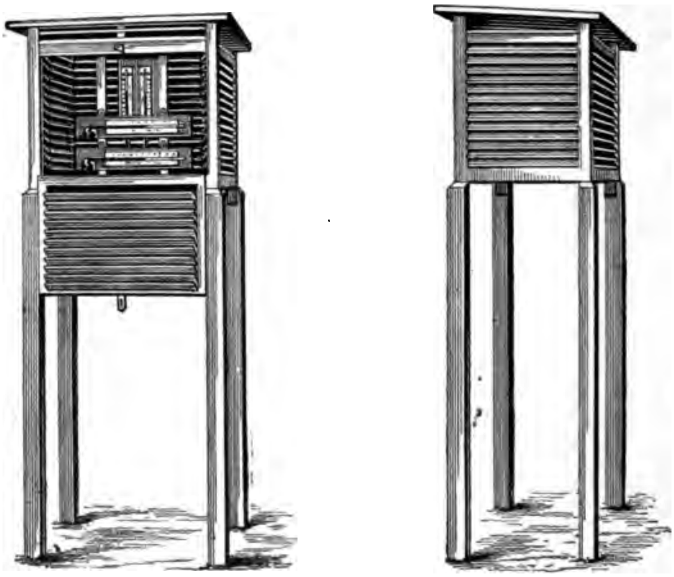

FIG. 1. FIG. 2.

Royal Meteorological Society's pattern, Stevenson Thermometer Screen.

deep, and 15 inches high; but the Stevenson screens usually supplied by meteorological instrument-makers were somewhat larger than the original pattern. No important alteration was, however, made in this form of screen until 1883, when a Committee was appointed by the Council of this Society to consider in what ways the screen might be improved.

In accordance with the recommendations of that Committee, a new screen was made, which was in internal dimensions 3½ inches wider, 3½ inches deeper, and 1½ inch higher than the original Stevenson.[1] This is the screen now known as the Royal Meteorological Society's pattern (Figs. 1 and 2, p. 72). The principal other improvements were in the louvres, which were joined together, instead of being separated at their upper edges, while the outer louvres were made an inch longer. The distance between the louvres was increased from ⅜ inch to a clear ½ inch. The new screen has a sloping roof, with a flat roof pierced with holes a few inches below it; whereas in the old screen there was only a single flat roof with a small metal ventilating pipe in the centre of it. The bottom of the screen consists of three narrow boards, the outer ones overlapping the inner one in such a way as to completely cut off radiation from below, while allowing free access of air; whereas the old screen was made either quite open below, or with only one narrow board across the centre.

Stevenson and Wall Screen.

Mr. Marriott, in 1879, fixed a pair of wall screens to the brick wall of an outhouse with a northern exposure, so that the screens were in the shade, except in the morning and afternoon of the summer months. The readings in the screens were compared with those of a Stevenson screen in the open for twelve months. The results show that the mean daily maximum temperature on the wall is below that in the open—the monthly differences varying from 0°0 to − 2°·1, that for the twelve months being − 1°·0. The mean minimum temperature on the wall was mostly higher than in the Stevenson screen, the differences varying from − 0°·1 to + 1°·3, the mean for the year being + 0°·5.[2]

Stevenson and Wild Screen.

During 1879, 1880, and 1881, the late Mr. G. M. Whipple instituted a series of comparisons at Kew Observatory, of which he was the Superintendent, between the readings of thermometers in a Stevenson screen and those in a Wild screen, placed, as recommended by Dr. Wild, inside a lofty and roomy single louvre-boarded screen with a close double roof. A description of the Wild screen will be given a little later on. The thermometers in the Stevenson screen were 4 feet, and those in the Wild screen 12 feet above the ground. The general conclusions were:—(1) That the mean daily temperature in a Stevenson screen only differs from that in a Wild screen by 0°·1. (2) That the greatest differences between the readings of the thermometers in the two screens were found to exist in calm weather, whereas in autumn and in windy weather the differences were very small.[3]

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[1] *Quarterly Journal Royal Met. Soc.*, vol. x. pp. 1 and 92.

[2] *Quarterly Journal Royal Met. Soc.*, vol. v. p. 217.

[3] *Quarterly Weather Report*, 1880, p. [13].

Stevenson and Glaisher Stand.

In 1887 a Stevenson screen of the new pattern was set up at Greenwich Observatory, near the Glaisher stand, and the results of the comparisons between the readings in the two screens were communicated to this Society in 1891 by Mr. W. Ellis, F.R.S. The mean daily excess of the Glaisher stand readings over those in the Stevenson screen at 9 p.m. were 0°·09, at noon 0°·19, at 3 p.m. 0°·11, and in the maximum 1°·16; whereas at 9 p.m., and the time of the minimum, the indications in the Glaisher stand were below those in the Stevenson by 0°·18 and 0°·41 respectively.[1]

My own experiments may be said to have commenced in 1877, when I placed at Croydon a Stevenson screen (Casella pattern) by the side of the Glaisher stand I had previously been using. The latter was in all respects similar to that set up by Mr. Symons in the Royal Botanic Gardens in 1870, which again was constructed exactly in accordance with the dimensions of the Greenwich pattern, as communicated by Mr. Glaisher to the *Meteorological Magazine*, vol. iii. p. 155, and from which dimensions also the Greenwich stand, used in the Strathfield Turgiss experiments, was constructed.

For five years these screens stood side by side in my garden (Fig. 3, p. 78), and readings were taken regularly three times a day—at 9 a.m., at 3 p.m., and at 9 p.m. The mean results show, as might have been expected, that during the daytime, as the year advances, and as the sun increases in power, the higher are the readings on the Glaisher stand above those in the Stevenson. But what would not have been, I think, anticipated, is that the differences during most of the year, including two of the summer months, are greater at 9 a.m. than at 3 p.m., and in five of the twelve months greater at that hour than at the time of the maximum (see Table I.).

TABLE I.—MEAN DIFFERENCES OF TEMPERATURE IN A GLAISHER STAND ABOVE OR BELOW THOSE IN A STEVENSON SCREEN OF THE PATTERN IN USE PREVIOUS TO 1883 FOR THE FIVE YEARS 1877-81.

January.

Year.	9 A.M.		3 P.M.		9 P.M.		Max.	Min.	Mean of Max. and Min.	Mean Daily Range.
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.				
1877	+0°·3	+0°·2	+0°·4	+0°·2	+0°·4	+0°·2	-0°·2	-0°·7	-0°·45	+0°·5
1878	+0·2	+0·1	0·0	+0·1	-0·1	0·0	0·0	-0·4	-0·20	+0·4
1879	0·0	+0·1	0·0	0·0	-0·1	0·0	+0·1	-0·7	-0·30	+0·8
1880	+0·1	+0·1	-0·2	-0·3	-0·1	0·0	-0·1	-1·0	-0·55	+0·9
1881	+0·2	+0·2	-0·1	0·0	-0·1	-0·1	+0·3	-1·2	-0·45	+1·5
Means	+0·16	+0·14	+0·02	0·00	0·00	+0·02	+0·02	-0·80	-0·39	+0·82
February.										
1877	+0·5	+0·3	+0·5	+0·4	+0·1	+0·3	+0·1	-0·8	-0·35	+0·9
1878	+0·3	+0·3	0·0	+0·1	-0·2	-0·1	0·0	-0·5	-0·25	+0·5
1879	+0·2	+0·2	+0·1	+0·1	-0·2	0·0	+0·2	-0·7	-0·25	+0·9
1880	0·0	+0·2	-0·1	0·0	-0·4	0·0	0·0	-0·9	-0·45	+0·9
1881	+0·1	+0·3	+0·1	+0·2	-0·1	0·0	-0·4	-0·8	-0·60	+0·4
Means	+0·22	+0·26	+0·12	+0·16	-0·16	+0·04	-0·02	-0·74	-0·38	+0·72

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[1] *Quarterly Journal Royal Met. Soc.*, vol. xvii. p. 240.

TABLE I.—MEAN DIFFERENCES OF TEMPERATURE—*Continued.*

Year.	9 A.M.		3 P.M.		9 P.M.		Max.	Min.	Mean of Max. and Min.	Mean Daily Range.
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.				
					March.					
	°	°	°	°	°	°	°	°	°	°
1877	+0·5	+0·3	+0·3	+0·2	-0·2	-0·2	+0·5	-0·8	-0·15	+1·3
1878	+0·4	+0·3	+0·1	+0·1	-0·2	-0·1	+0·3	-0·6	-0·15	+0·9
1879	+0·5	+0·4	+0·2	+0·2	-0·4	-0·2	+0·1	-0·8	-0·35	+0·9
1880	+0·5	+0·4	+0·2	-0·1	-0·4	-0·2	+0·6	-1·0	-0·20	+1·6
1881	+0·4	+0·4	+0·1	+0·2	-0·4	-0·2	+0·3	-1·1	-0·40	+1·4
Means	+0·46	+0·36	+0·18	+0·12	-0·32	-0·18	+0·36	-0·86	-0·25	+1·22
					April.					
1877	+0·9	+0·7	+1·0	+0·5	0·0	0·0	+0·9	-0·7	+0·10	+1·6
1878	+0·7	+0·4	+0·6	+0·3	-0·3	-0·2	+0·9	-0·7	+0·10	+1·6
1879	+0·5	+0·4	+0·5	+0·2	-0·4	-0·2	+0·9	-0·8	+0·05	+1·7
1880	+0·7	+0·4	+0·5	+0·2	-0·5	-0·3	+0·9	-1·0	-0·05	+1·9
1881	+0·7	+0·6	+0·4	+0·2	-0·3	-0·2	+0·8	-1·0	-0·10	+1·8
Means	+0·70	+0·50	+0·60	+0·28	-0·30	0·18	+0·88	-c·84	+0·02	+1·72
					May.					
1877	+1·5	+1·0	+1·3	+1·0	+0·1	+0·1	+1·2	-0·8	+0·20	+2·0
1878	+1·0	+0·7	+0·9	+0·5	-0·3	-0·1	+1·2	-0·5	+0·35	+1·7
1879	+0·9	+0·6	+0·7	0·0	-0·4	-0·3	+1·2	-0·8	+0·20	+2·0
1880	+1·1	+0·8	+0·6	0·0	-0·5	-0·4	+1·2	-0·9	+0·15	+2·1
1881	+1·0	+0·6	+0·8	+0·3	-0·5	-0·3	+1·0	-1·0	0·00	+2·0
Means	+1·10	+0·74	+0·86	+0·36	-0·32	-0·20	+1·16	-0·80	+0·18	+1·96
					June.					
1877	+1·7	+1·0	+1·8	+1·0	0·0	-0·2	+1·6	-0·7	+0·45	+2·3
1878	+1·3	+0·8	+1·3	+0·7	-0·4	-0·2	+1·4	-0·8	+0·30	+2·2
1879	+0·8	+0·4	+1·2	+0·5	-0·5	-0·1	+1·4	-0·6	+0·40	+2·0
1880	+0·9	+0·5	+0·9	+0·4	-0·5	-0·2	+1·3	-0·6	+0·35	+1·9
1881	+1·1	+0·5	+1.0	+0·5	-0·4	-0·2	+1·4	-0·8	+0·30	+2·2
Means	+1·16	+0·64	+1·24	+0·62	-0·36	-0·18	+1·42	-0·70	+0·36	+2·12
					July.					
1877	+1·5	+0·6	+1·4	+1·2	+0·2	0·0	+1·8	-0·8	+0·50	+2·6
1878	+1·3	+0·7	+0·8	+0·4	-0·5	0·0	+1·3	-0·8	+0·25	+2·1
1879	+0·7	+0·5	+0·9	+0·6	-0·3	0·0	+1·2	-0·5	+0·35	+1·7
1880	+1·0	+0·5	+1·2	+0·6	-0·4	-0·2	+1·6	-0·7	+0·45	+2·3
1881	+0·9	+0·1	+0·7	-0·3	-0·6	-0·4	+1·1	-0·8	+0·15	+1·9
Means	+1·08	+0·48	+1·00	+0·50	-0·32	-0·12	+1·40	-0·72	+0·34	+2·12

TABLE I.—MEAN DIFFERENCES OF TEMPERATURE—*Continued.*

Year.	9 A.M.		3 P.M.		9 P.M.		Max.	Min.	Mean of Max. and Min.	Mean Daily Range.
	Dry.	Wet.	Dry.	Wet.	Dry.	Wet.				
					August.					
	°	°	°	°	°	°	°	°	°	°
1877	+ 1·2	+ 0·6	+ 0·8	+ 0·3	- 0·3	- 0·2	+ 1·2	- 0·2	+ 0·50	+ 1·4
1878	+ 1·1	+ 0·5	+ 1·0	+ 0·4	- 0·3	- 0·2	+ 1·2	- 0·6	+ 0·30	+ 1·8
1879	+ 0·8	+ 0·4	+ 0·7	+ 0·2	- 0·3	- 0·0	+ 1·1	- 0·7	+ 0·20	+ 1·8
1880	+ 0·9	+ 0·5	+ 0·6	+ 0·3	- 0·4	- 0·3	+ 1·1	- 0·5	+ 0·30	+ 1·6
1881	+ 0·6	+ 0·3	+ 0·7	+ 0·2	- 0·4	- 0·2	+ 0·9	- 0·8	+ 0·05	+ 1·7
Means	+ 0·92	+ 0·46	+ 0·76	+ 0·28	- 0·34	- 0·18	+ 1·10	- 0·56	+ 0·27	+ 1·66
					September.					
1877	+ 0·8	+ 0·4	+ 0·6	+ 0·2	- 0·4	- 0·4	+ 0·7	- 0·5	+ 0·10	+ 1·2
1878	+ 1·1	+ 0·7	+ 0·7	+ 0·2	- 0·5	- 0·2	+ 1·0	- 0·7	+ 0·15	+ 1·7
1879	+ 0·7	+ 0·5	+ 0·3	+ 0·2	- 0·2	0·0	+ 0·7	- 0·8	- 0·05	+ 1·5
1880	+ 0·8	+ 0·3	+ 0·4	+ 0·2	- 0·4	- 0·1	+ 0·8	- 0·9	- 0·05	+ 1·7
1881	+ 0·6	+ 0·5	+ 0·3	+ 0·1	- 0·4	0·2	+ 0·6	- 0·9	- 0·15	+ 1·5
Means	+ 0·80	+ 0·48	+ 0·46	+ 0·18	0·38	0·18	+ 0·76	- 0·76	0·00	+ 1·52
					October.					
1877	+ 0·6	+ 0·2	+ 0·2	- 0·1	- 0·3	0·2	+ 0·3	- 0·6	- 0·15	+ 0·9
1878	+ 0·4	+ 0·4	+ 0·2	- 0·1	0·2	0·1	+ 0·4	- 0·7	- 0·15	+ 1·1
1879	+ 0·3	+ 0·4	- 0·1	+ 0·3	0·4	0·0	+ 0·4	- 0·8	- 0·20	+ 1·2
1880	+ 0·3	+ 0·3	- 0·1	0·0	0·2	0·1	+ 0·1	0·8	- 0·35	+ 0·9
1881	+ 0·3	+ 0·4	- 0·2	0·0	- 0·6	- 0·1	+ 0·2	- 0·9	- 0·35	+ 1·1
Means	+ 0·38	+ 0·34	0·00	+ 0·02	- 0·34	- 0·10	+ 0·28	- 0·76	- 0·24	+ 1·04
					November.					
1877	+ 0·1	+ 0·2	- 0·2	0·1	- 0·4	- 0·1	- 0·1	- 0·5	- 0·30	+ 0·4
1878	+ 0·2	+ 0·2	- 0·2	- 0·1	- 0·1	- 0·2	- 0·2	- 0·5	- 0·35	+ 0·3
1879	+ 0·2	+ 0·4	- 0·1	+ 0·1	- 0·3	- 0·1	0·0	- 1·0	- 0·50	+ 1·0
1880	0·0	+ 0·2	- 0·3	- 0·1	- 0·3	- 0·1	- 0·1	- 1·1	- 0·60	+ 1·0
1881	- 0·2	+ 0·1	- 0·3	0·0	- 0·3	0·1	- 0·2	- 0·8	- 0·50	+ 0·6
Means	+ 0·06	+ 0·22	- 0·22	- 0·04	- 0·28	0·12	- 0·12	- 0·78	- 0·45	+ 0·66
					December.					
1877	- 0·1	0·0	0·2	- 0·2	- 0·1	- 0·1	- 0·1	- 0·5	- 0·30	+ 0·4
1878	+ 0·1	+ 0·2	0·0	0·0	0·0	0·0	0·0	- 0·7	- 0·35	+ 0·7
1879	+ 0·1	+ 0·1	- 0·2	0·1	- 0·1	- 0·1	- 0·1	- 1·0	- 0·55	+ 0·9
1880	- 0·1	0·0	- 0·3	- 0·1	- 0·3	- 0·1	- 0·5	- 0·7	- 0·60	+ 0·2
1881	- 0·3	- 0·1	- 0·3	0·2	0·3	- 0·1	- 0·4	- 0·9	- 0·65	+ 0·5
Means	- 0·06	+ 0·04	- 0·20	0·12	- 0·16	- 0·08	- 0·22	- 0·76	- 0·49	+ 0·54

From the above five years' observations, I have endeavoured to find out what were the special conditions which caused the differences between the indications of the thermometers in these two screens to be at times so large.

That it was not due to the wind blowing on any particular side of the Stevenson screen was soon ascertained. I took in each case the first 30 instances during the summer months, when the wind at 3 p.m. came respectively from some Northerly, Easterly, Southerly or Westerly point, and found that the mean differences in the maxima readings came out as follows:—

	°
When the wind was blowing on the North side the mean maximum was higher on the Glaisher stand by	1·4
When on the East side by	1·5
When on the South side by	1·5
When on the West side by	1·5

I next took out all the instances (nearly 100) when the temperature during the summer was, at 3 p.m., more than 1°·5 higher on the Glaisher stand than in the Stevenson screen, the mean of all these variations amounting to 2°·1.

The temperature was found on an average to be 67°·9. Considering that the mean temperature at 3 p.m. for the three summer months in the five years comes out as 66°·2, the readings could have been, as a rule, on these occasions only moderately warm for the season. In fact, on only two days did the temperature exceed 80°. These unusual differences could therefore not be due to great heat.

That the weather on those days at the same hour was, as a rule, bright, for the season, is shown by the mean amount of cloud, 5·7—the mean for the three months in the five years being 6·8. On the other hand, on 27 of the 100 days the amount of cloud ranged between 8 and 10.

That the heat from the sun was greater than usual on the days when the Glaisher stand thermometers read higher at 3 p.m. than those in the Stevenson, is evident from the registrations of the black bulb thermometer *in vacuo*, the mean being 124°·8, against an average of 119°·0.

That the unusual differences were not caused by great calmness of the air, is proved by the mean velocity of the wind at 3 p.m. on these particular days being 7·4 miles an hour (using factor 2·2), the mean at the same hour for the three months in the five years being 7·8 miles an hour.

The conditions therefore most favourable to the production of unusual differences in the indications on the two screens appear to be—summer weather rather above the average in temperature, with the sky about half covered with clouds, and when the sun's rays are unusually powerful, and the wind is of about average strength.

Royal Meteorological Society's Screen.

In 1883, at the request of the Council of this Society, I compared the readings of thermometers in the Stevenson screen I had then in use (Casella pattern) with those mounted in a Stevenson screen of the new pattern.[1] This series of comparisons was made on my lawn at Croydon during the months of July, August, and September (Fig. 3). The mean results may be briefly summed up as follows. The temperatures in the two screens were virtually the same at night, and also at 9 a.m. During the hottest part of the day, however, and also at 9 p.m., the new screen proved itself a trifle cooler than the old screen. The mean temperature also came out slightly lower from the new screen readings, as also did the daily range. Taken as a whole the indications were very similar, the differences between the individual temperatures at any hour seldom exceeding 0°·5.

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[1] *Quarterly Journal Royal Met. Soc.*, vol. x. p. 1.

Shaded and Unshaded Screens.

In the following year I set up two screens of the Royal Meteorological Society's pattern on my lawn at Croydon, fitted with precisely similar maximum and minimum thermometers, in order to test to what extent such a screen became heated in the middle of the day during the hottest part of the year. The roof of one of the screens was accordingly protected with canvas stretched a short distance above it, while all the louvres, except those on the north side, were screened from the sun by means of three strips of canvas stretched on stiff wires, which projected about 3 inches from the sides of the screen (Fig. 3). These experiments showed that on the 9 hottest days of the year the readings of the maximum thermometer in the shaded screen averaged only 0°·2 below those in the exposed screen.

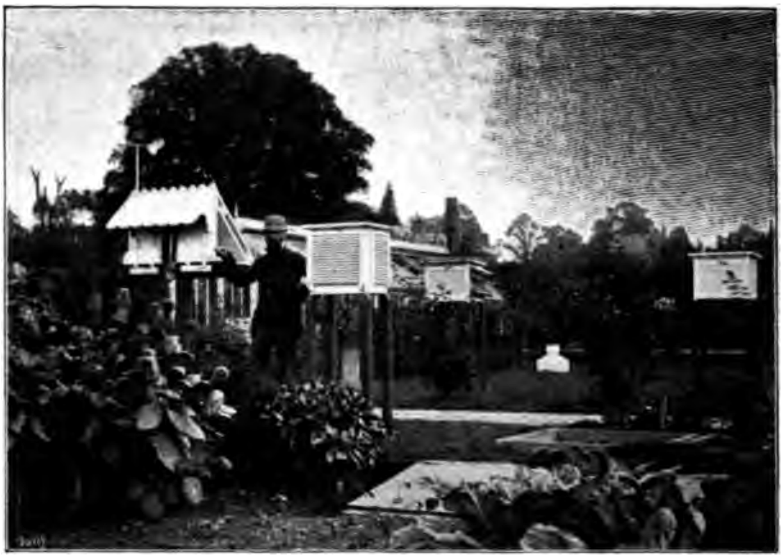

FIG. 3.—Thermometer Screen Experiments at Croydon, 1883.

Taking the temperature at 3 p.m. on the 7 hottest days, all the readings being above 75°, the mean in the shaded screen came out 78°·6, in the unshaded screen 78°·3, and those of a sling thermometer, swung in full sunshine near the screens, 78°·5.

During the past summer I have repeated these experiments, under somewhat cooler conditions as regards weather, with the following unexpected results (see Table II.). In the latter half of August, when the comparisons were first made, there was virtually no difference in the mean of the maximum temperatures. In September the shaded screen came out 0°·1 warmer, in October there was no difference, in November the shaded screen was 0°·1 warmer, and in December 0°·5 warmer. All the mean minima were, on the other hand, 0°·1 cooler in the shaded than in the unshaded screen. Examining the tables a little more in detail for August, September, and October, and selecting those days which were unusually sunny, the highest temperatures in the shaded screen were found to be, in all but one instance, when the readings were alike, from 0°·1 to 0°·5 cooler than in the unshaded; whereas on all the exceptionally dull days the maximum readings were in nearly every instance from 0°·1 to 0°·9 warmer.

TABLE II.—TEMPERATURES IN A STEVENSON SCREEN SHADED WITH CANVAS PROJECTIONS AND ROOF, ABOVE OR BELOW THOSE IN A SIMILAR SCREEN UNSHADED.

1896.	No. of Obs.	Max.	No. of Obs.	Min.	Mean of Max. and Min.	Mean Daily Range.
		°		°	°	°
August	10	+0·02	7	-0·12	-0·05	+0·14
September	25	+0·10	25	-0·11	-0·00	+0·21
October	29	-0·02	24	-0·16	-0·09	+0·14
November	25	+0·10	17	-0·08	+0·01	+0·18
December	18	+0·49	19	-0·12	+0·19	+0·61

It is not easy to understand why in dull weather the shaded screen should be warmer in the daytime than the unshaded, and at night be almost invariably cooler. Be the reason what it may, one thing comes out very clearly, and that is, that in all but the hottest weather the Stevenson screen never becomes sufficiently heated on the outside to influence the thermometers to an appreciable extent, when they are properly suspended in it.

In order to ascertain the difference between the readings of thermometers in deep shade and those in a screen exposed to full sunshine, I, at Mr. Marriott's suggestion, placed a Stevenson screen under a horse-chestnut tree only about 20 yards distant from another screen of precisely

TABLE III.—TEMPERATURES IN A STEVENSON SCREEN IN THE SHADE OF A HORSE-CHESTNUT TREE, ABOVE OR BELOW THOSE IN A SIMILAR SCREEN IN THE OPEN.

1896.	Max.	Min.	1896.	Max.	Min.
	°	°		°	°
August 7	-1·7	+0·8	August 15	-1·3	+1·1
,, 8	+0·5	+0·4	,, 16	-2·6	+0·6
,, 9	-0·9	+0·3	,, 17	-1·1	+0·5
,, 10	-0·8	0·0	,, 18	-0·6	-0·2
,, 11	-1·4	0·0	,, 19	-3·1	+0·4
,, 12	-1·4	+0·2	,, 20	-1·6	0·0
,, 13	-2·2	+1·3	,, 21	+0·3	+0·2
,, 14	-2·3	...			
			Means	-1·35	+0·40

the same pattern (see Table III.). The differences in the day readings, as might have been expected, were at times considerable, owing to the foliage of the tree being so thick and the branches descending so low that at no time could any sunshine reach the grass beneath the screen in shadow, or any part of the lawn for yards round it. During the first fortnight in August that this experiment lasted, the maxima in the screen under the tree were on an average 1 ·3 lower than those in the Stevenson in the open, and the minima, on the other hand, 0°·4 higher. The greatest differences in the maxima did not occur on the warmest days, but on days when radiation was evidently most active.

Stevenson and French Screens.

I thought it would also be of interest if I compared the temperatures in our own English thermometer screen—the Stevenson—with those in two of the leading screens in use on the Continent. I accordingly had a wooden screen made after the pattern in use in France, and known as the Montsouris pattern. It is an open screen, somewhat after the type of the Glaisher stand, but much larger and higher. The thermometers, which are well protected at all seasons from the direct rays of the sun, are placed 5 feet and 5 feet 6 inches above the ground, and close under the large sloping double roof. It was erected on the same strip of lawn with the Stevenson screen, from which it was distant only about 10 yards (Fig. 4). As in the case of the Glaisher stand the difference in the readings in the French screen were, as a rule, greater than those in the Stevenson at 9 a.m. than at 3 p.m. (see Table IV.). During the spring and summer the

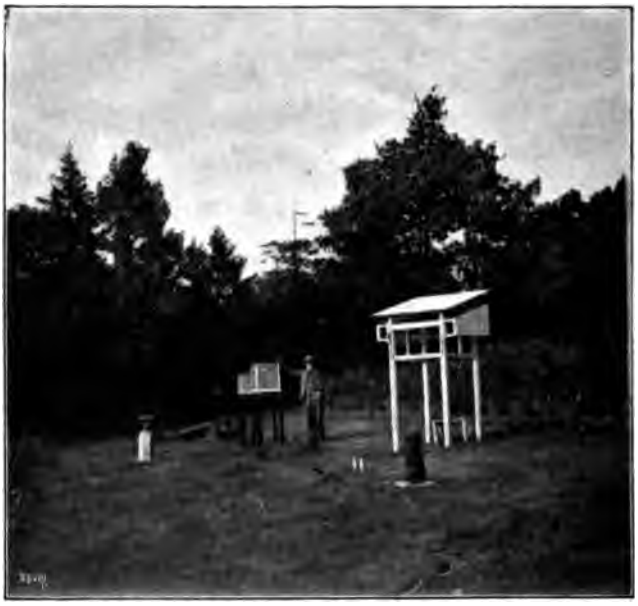

FIG. 4.—French and Stevenson Screens at Berkhamsted, 1896.

maxima readings were higher than in the Stevenson, but in the autumn and winter somewhat lower; while the minima temperatures differed but slightly from those in the Stevenson screen. It is, in fact, an improved Glaisher stand, as it requires no turning, and the thermometers being placed higher, are less influenced by radiation from the ground; and the roof being larger, the night temperatures do not fall so low, owing to direct radiation to the sky being almost completely cut off.

TABLE IV.—MEAN DIFFERENCES OF TEMPERATURE IN A FRENCH SCREEN ABOVE OR BELOW THOSE IN A STEVENSON SCREEN OF THE ROYAL METEOROLOGICAL SOCIETY'S PATTERN, FOR THE NINE MONTHS ENDING DECEMBER 1896.

1896.	9 A.M.			3 P.M.			No. of Observations.	Max.	No. of Observations.	Min.	Mean of Max. and Min.	Mean Daily Range.
	No. of Obs.	Dry.	Wet.	No. of Obs.	Dry.	Wet.						
April . .	19	+0°·90	+0°·77	19	+0°·23	+0°·44	16	+0°·29	16	+0°·03	+0°·16	+0°·26
May . .	31	+1·21	+1·20	31	+1·18	+1·26	25	+1·78	25	-0·03	+0·87	+1·81
June . .	30	+0·71	+0·59	30	+0·73	+0·68	24	+1·04	24	+0·05	+0·55	+0·99
July . .	30	+1·18	+0·89	30	+0·96	+0·92	23	+0·79	23	-0·03	+0·38	+0·82
August .	31	+0·59	+0·41	31	+0·40	+0·44	25	+0·32	25	-0·15	+0·08	+0·47
September	30	+0·69	+0·54	29	+0·19	+0·35	24	0·00	24	-0·08	-0·04	+0·08
October .	31	+0·69	+0·48	31	-0·02	+0·17	23	-0·34	23	-0·14	-0·24	-0·20
November	30	+0·61	+0·41	30	-0·03	+0·15	22	-0·20	18	-0·09	-0·15	-0·11
December	31	+0·35	+0·33	31	-0·01	-0·02	19	-0·17	19	-0·25	-0·21	+0·08
Means	29	+0·77	+0·62	29	+0·40	+0·49	22	+0·39	22	-0·08	+0·16	+0·47

Stevenson and Russian Screens.

The other foreign screen I experimented with was a metal screen devised by Dr. Wild, and used in Russia and some parts of Germany.

TABLE V.—MEAN DIFFERENCES OF TEMPERATURE IN A RUSSIAN SCREEN ABOVE OR BELOW THOSE IN A STEVENSON SCREEN OF THE ROYAL METEOROLOGICAL SOCIETY'S PATTERN, FOR THE NINE MONTHS ENDING DECEMBER 1896.

1896.	9 A.M.			3 P.M.			No. of Observations.	Max.	No. of Observations.	Min.	Mean of Max. and Min.	Mean Daily Range.
	No. of Obs.	Dry.	Wet.	No. of Obs.	Dry.	Wet.						
April . .	17	+1°·73	+1°·64	17	-0°·37	+0°·71	12	-0°·81	12	+0°·15	-0°·33	-0°·96
May . .	25	+1·88	+1·80	25	-0·36	+0·72	20	-0·62	20	+0·46	-0·08	-1·08
June . .	25	+2·43	+2·06	25	+0·22	+1·33	23	+0·73	23	+0·29	+0·51	+0·44
July . .	26	+2·72	+2·30	26	+0·04	+1·31	21	-0·25	21	+0·45	+0·10	-0·70
August .	28	+1·60	+1·48	23	-0·15	+0·79	14	-0·26	24	+0·12	-0·07	-0·38
September	25	+1·29	+1·28	24	-0·44	+0·32	...	...	20	-0·28	...	...
October .	27	+0·50	+0·70	27	-0·87	+0·06	14	-0·30	20	-0·29	-0·30	-0·01
November	25	+0·08	+0·19	25	-0·94	-0·15	19	-0·21	17	-0·37	-0·29	+0·16
December	27	+0·08	+0·17	24	-0·34	+0·05	18	+1·03	17	-0·32	+0·35	+1·35
Means	25	+1·37	+1·29	24	0·36	+0·57	18	-0·09	19	+0·02	-0·01	-0·15

The one I have came direct from Berlin, and was sent me by Dr. Hellmann.

It consists of two concentric zinc cylinders, enamelled white, and separated by an air space, with an enamelled zinc ventilated roof. Instead of placing this screen in a lofty louvre-boarded screen erected in the open, as was done by the late Mr. Whipple in his experiments at Kew in 1880, the screen sent me was placed outside a north window of my house, as is a common practice in the countries named. The screen, when in position, remains suspended 3 feet away from the wall, and by an ingenious arrangement is capable of being drawn opposite the window whenever a reading is required to be made; and in doing so the front of the screen opens for the thermometers to be read or set, and closes again when pushed back into its proper position (Figs. 5 and 6). This is no doubt an excellent screen for cold climates, where, owing to deep snow, it is often almost impossible to visit a thermometer screen in the open ground, and where the screen would be often buried.

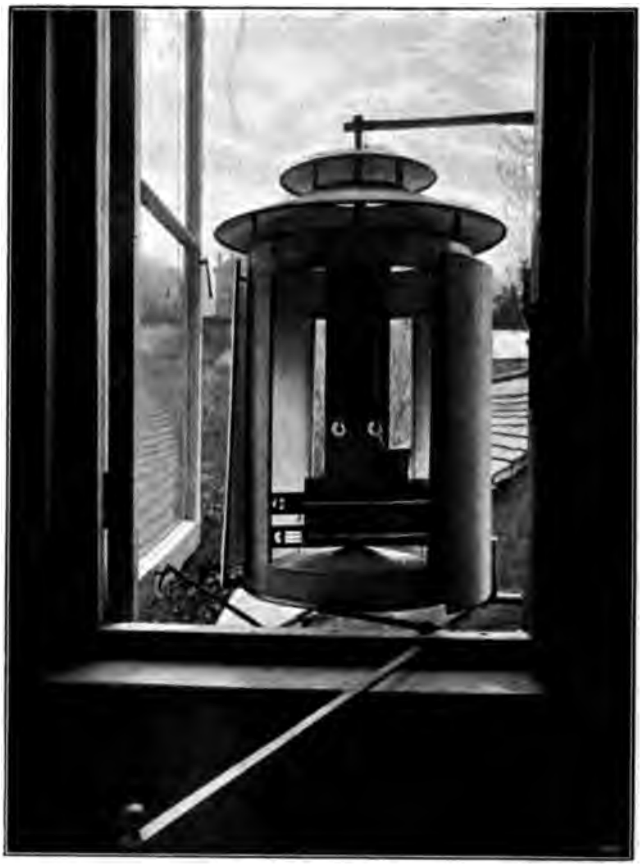

FIG. 5.—Russian Screen open.

In the hottest part of the day the thermometers in it read lower than in a Stevenson screen during the greater part of the year, but higher at night through the spring and summer (see Table V.). This screen, however, appears to require some protection from the sun during those morning hours in the summer when it is not in the shadow of the house, the readings at 9 a.m. being on an average 2° to 3° higher than in the Stevenson; whereas at 3 p.m. the mean differences are very slight, and at the time of the maximum are all lower than in the Stevenson screen.

Open versus *Closed Screens.*

The practical end I have kept in view in making all these comparisons, has been to try and ascertain which screen now in use most nearly fulfils the conditions before referred to, as laid down at that memorable meeting of the Society in 1879, and which I do not think can very well be improved upon.

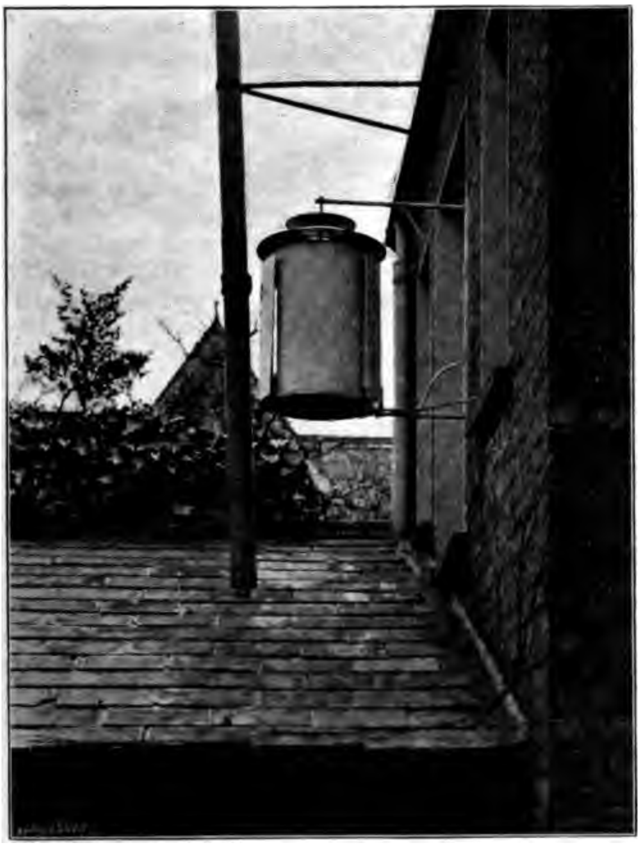

Fig. 6.—Russian Screen closed.

Testing all the screens I have mentioned by these rules, the best two appear to me to be the Stevenson and the French, the former being the best type of closed screen yet devised, and the latter the best form of open screen. The weak points in the French screen are the following.

The thermometers being suspended from 5 feet to 5 feet 6 inches above the ground are too high to be read without the aid of steps. Their bulbs are affected by radiation of heat from the ground beneath them during the spring and summer. They are, moreover, exposed to reflected heat from surrounding objects on the north side. The stand itself is too large to be readily portable by rail or otherwise; and its cost is about double that of the Stevenson screen. Moreover, the thermometers are exposed at times to driving rain and snow. On the other hand, there is no other screen I know of in which the thermometers are better protected from the direct rays of the sun, and at the same time almost equally well from the influence of nocturnal radiation, or where the access of air to the bulbs is freer or more natural.

Objections to Stevenson Screen met.

The only two objections I have ever seen raised to the Stevenson screen are:—(1) That in hot weather it becomes heated by the sun to such an extent that the temperatures indicated in it are materially affected. (2) That the louvres are so close together, that in anything like calm weather, the air does not circulate properly round the thermometers; and consequently both the temperature and humidity observations taken in them are higher than they otherwise would be. Now both these points are curiously enough, as we have just seen, the very ones in which the typical open screen, the French, gives the best results.

Even without experiment it might be inferred that a closely-louvred box, like the Stevenson screen, set up in the full rays of the sun, must, to a certain extent, cause the air enclosed within it to become warmer than the external atmosphere, and also check the flow of air to the thermometer bulbs. Considering how nearly perfect this form of thermometer exposure is in all other respects, I have endeavoured to ascertain whether this heating up of the Stevenson screen takes place to any serious extent in hot weather; and also whether the circulation of air in the screen is also injuriously affected.

The experiments I made at Croydon, and also at Berkhamsted, with a Stevenson screen shaded with canvas, which have previously been described, show clearly that in the very hottest weather, provided the thermometers are arranged in the screen in accordance with the instructions issued by the Society, the temperature in it is raised by the sun heating the louvres less than a quarter of a degree, and in ordinary summer weather to no appreciable extent.

In order to see how these results were borne out by temperatures, registered inside the screen by a maximum thermometer suspended close to the louvres, I placed such a thermometer alternately near the east, south, and west louvres, from the middle of August last until the end of September. The mean of all the readings so taken, and of those registered by a maximum thermometer properly placed in the centre of the screen, came out alike for the east side—the maximum temperature being as often slightly lower as higher, near the louvres as away from them; but on the south side the thermometer close to the louvres read on an average 0°·4 higher (the extreme variations ranging between 0°·0 and + 0°·6), and on the west side averaged 0°·1 (the extreme variations ranging between - 0°·3 and + 0°·8). (See Table VI.) Surely such small differences as these may be regarded as insignificant, particularly when it is borne in mind that all screens of this pattern are likely to be affected in the same way and to the same slight extent.

TABLE VI.—TEMPERATURES INDICATED BY A MAXIMUM THERMOMETER SUSPENDED CLOSE TO THE LOUVRES ON THE EAST, SOUTH, AND WEST SIDES OF A STEVENSON SCREEN ABOVE OR BELOW THOSE OF A MAXIMUM THERMOMETER PROPERLY PLACED IN THE SCREEN.

1896.	Temp. in Stevenson.	E. Side.	S. Side.	W. Side.	1896.	Temp. in Stevenson.	E. Side.	S. Side.	W. Side.
Aug.	°	°	°	°	Sept.	°	°	°	°
17	71·4	+0·1	...	...	9	67·2	0·0	...	...
19	69·1	...	+0·4	...	11	64·3	...	...	0·0
20	69·6	...	...	+0·6	12	62·0	-0·1	...	...
21	64·4	+0·1	...	...	13	62·0	...	+0·3	...
22	67·8	...	+0·4	...	14	65·0	...	...	-0·1
23	74·0	...	...	+0·1	15	66·0	+0·2	...	...
24	65·6	0·0	...	...	16	65·6	...	+0·6	...
25	66·6	...	+0·4	...	17	59·4	...	...	-0·1
26	61·3	...	...	-0·3	18	62·2	0·0	...	...
27	65·2	+0·2	...	...	19	63·0	...	+0·2	...
28	64·8	...	+0·4	...	20	61·5	...	...	-0·3
29	65·2	...	...	+0·2	22	63·6	...	0·0	...
30	64·1	+0·2	...	...	23	60·6	...	...	-0·3
31	66·0	...	+0·4	...	24	61·3	-0·1	...	...
Sept.					25	59·4	...	+0·2	...
1	60·4	...	...	+0·8	27	64·1	+0·1	...	...
3	66·8	...	+0·6	...	28	58·7	...	+0·5	...
4	60·0	...	...	+0·1	29	56·9	...	...	+0·2
5	67·6	-0·1	...	...	30	63·2	-0·5	...	...
7	68·0	...	+0·4	...					
8	70·6	...	...	+0·4		Means	+0·01	+0·37	+0·10

The only way of finding out whether the circulation of air in the Stevenson screen was seriously checked by the closeness of the louvres that occurred to me, was by comparing the relative humidities obtained from the dry and wet bulb observations in one of these screens, and also in an open screen. Taking first the 5 years' observations at Croydon in my Stevenson and Glaisher stands, the mean relative humidity for the three summer months came out 60 per cent at 3 p.m. for the Glaisher and 62 per cent for the Stevenson, or 2 per cent higher for the latter than for the former, the mean differences for the separate months being from 1 per cent to 3 per cent. With a view to discover whether the differences varied with the strength of the wind, I took out all the instances where the variations at 3 p.m. exceeded 3 per cent during the 5 Julys of the same period, with the result that the average velocity of the wind on these occasions was 6½ miles an hour, against 7½ miles an hour, when the differences in the humidities amounted to 1 per cent or less.

Again, selecting those days in the summer when the rate of movement of the air at 50 feet above ground was 4 or less miles an hour at 3 p.m., and dividing them into three groups, the differences in the relative humidities were found to be as follows:—With an overcast sky they were 3 per cent higher for the Stevenson screen than for the Glaisher, with a cloudy sky also 3 per cent higher, and with a cloudless sky 2 per cent higher. Which shows, if the test I had chosen be any guide at all, that the circulation of air in the Stevenson screen is virtually as satisfactory in calm as in windy weather. It should be here stated that the Stevenson screen (Casella pattern) used in the above experiments had rather closer louvres than the modern type, and was somewhat smaller.

I have said that in no screen with which I am acquainted is the access of air to the thermometer bulbs freer or more natural than in the French stand. Consequently a comparison between the relative humidities obtained from my French screen and a Stevenson screen of the modern pattern may be of interest. The mean results at 3 p.m. for the three summer months of the past year are as follows:—In June and July the humidities were exactly alike, and in August the difference only amounted to 1 per cent in favour of the French screen. It may here be mentioned in passing, that the mean humidities at the same hour and for the same months in the Russian screen, were in excess of those in the Stevenson by 3 per cent in June, and by 4 per cent in July and August. The exposure in the Glaisher stand is not quite so natural as in the French, for the thermometer bulbs being suspended just below the north edge of the horizontal board, they are on the north side, what I may here term, naturally exposed, but on the south side are in contact with air in deep shade, and we all know how an artificial current of air must be often created under such conditions.

Every endeavour was made to render the observations carried out, for the purpose of the foregoing experiments, as accurate as possible. The readings were all taken punctually at the hours of observation, the thermometers were tested before and after the experiments had been made, the cotton and muslin on the wet bulb thermometers were kept scrupulously clean, and the different screens (except in the case of the Russian screen, which was given the best north exposure available) were placed in freely exposed positions over short grass.

If the conclusions at which I have arrived be to any extent correct, we have every reason, I think, to be proud of our national thermometer screen, the Stevenson, and particularly of that version of it known as the Royal Meteorological Society's pattern. But there is another practical point of far greater importance than that of what particular form of screen will give temperatures which approximate more closely to the true temperature of the air than those secured by other means, and that is, that the results obtained in such a screen should be intercomparable with those made in similar screens set up in other localities, even where the surroundings may not be exactly the same. And it is here again that a closed screen like the Stevenson has an advantage over all open screens.

International Comparisons.

It has long been the dream of all thoughtful meteorologists that, as far as circumstances will allow, an uniform method of taking all meteorological observations should be adopted throughout the world. This dream must, I feel sure, be ultimately realised, although few of us here present may be alive to witness its realisation. A step in the desired direction has, however, been recently made, and dealing, too, with the most important element of all, as I pointed out at the beginning of this address, air temperatures. For at the meeting of the International Meteorological Congress held in Paris in September last, one of our Secretaries, Mr. G. J. Symons, F.R.S., recommended that there should be established in each country one or more double meteorological stations for the comparison of the local systems of each country with an uniform international system to be decided upon at a future meteorological conference. It was too much to hope that such a resolution would be carried in its complete form. But it is, nevertheless, very gratifying to be told, as we were at our November meeting, that it was ultimately resolved that at one station, at least, in each country, in addition to the ordinary thermometer stand, other methods of exposure shall be simultaneously employed, the forms selected being the Stevenson screen, the French stand, and the aspiration arrangement of Assmann.

In conclusion, I tender my best thanks to Mr. Scott, and also to Mr. Symons, for the assistance they have kindly given me in the preparation of this address, the former in respect to foreign screens, and the latter for several valuable hints as to the comparison of those used in this country.

REPORT OF THE COUNCIL

FOR THE YEAR 1896.

In presenting their Report for the year just elapsed, the Council have again to congratulate the Society on its steady and uninterrupted progress during the past year, there being an increase in the number of Fellows, while the finances of the Society remain in a satisfactory condition.

The Council feel that the Society will regret the numerous losses by death sustained during the year, particularly those of one of the Vice-Presidents, Robert William Peregrine Birch; of two of the oldest Fellows, Isaac Brown and Edward Owen Tudor; of the Rev. William Clement Ley, so well known in connection with meteorological science; and also of Edwin James Horstman, the senior assistant in the Society's office.

The deaths of Mr. Isaac Brown and Mr. Edward Owen Tudor remove two of the small band of those who took part nearly fifty years ago in promoting the foundation of the British Meteorological Society. The British (now the Royal) Meteorological Society was founded on April 3, 1850, and these two gentlemen joined it on June 4 following.

Of those who were either Founders (marked *) or were elected in the first year, we still have with us the following Fellows:—

*Glaisher, J., F.R.S.
Hippisley, J., F.R.S.
*Johnson, W., F.R.A.S.
*Lowe, E. J., F.R.S.
Perigal, H., F.R.A.S.
Prince, C. L., F.R.A.S.
*Slatter, Rev. J., F.R.A.S.

Committees.—The Council have been materially assisted by several Committees, which were constituted as follows:—

EDITING COMMITTEE.—Mr. Inwards, Rear-Admiral Maclear, and Mr. Scott.

GENERAL PURPOSES COMMITTEE.—The President, Secretaries, Foreign Secretary, Treasurer, Messrs. Brewin, Ellis, Inwards, and Dr. Theodore Williams.

WIND FORCE COMMITTEE.—The President, Secretaries, Foreign Secretary, Messrs. Chatterton, Curtis, Dines, C. Harding, Munro, and Captain Wilson-Barker.

HOUSE ACCOMMODATION COMMITTEE.—The President, Secretaries, Foreign Secretary, Messrs. Inwards, Latham, and Dr. Theodore Williams.

Lecture.—In the month of March the premises of the Institution of Civil Engineers were not available for an exhibition, such as has been held in some former years. A lecture, in lieu thereof, was delivered on March 18 by Mr. F. Gaster. The subject was "Weather Forecasts and Storm Warnings. How they are prepared and disseminated." This lecture, which was illustrated by numerous photographs and charts, was much appreciated by the large audience present on the occasion, and has been printed in the *Quarterly Journal.*

Investigations.—The Council have directed investigations to be carried out (1) as to the difference in the results obtained from the Campbell-Stokes and the Jordan Sunshine Recorders, and (2) as to the influence of different heights above the ground on the force of the wind.

(1) The experiments with the two sunshine recorders are being made by Mr. E. T. Dowson at Geldeston, near Beccles, Norfolk, and the results tabulated by Mr. R. H. Curtis.

(2) With respect to the wind observations, five of Dines' pressure tube anemometers have been obtained, and through the kindness of Captain Wilson-Barker, have been erected on H.M.S. *Worcester*, off Greenhithe, at different heights above the deck, and the instruments are read at regular hours by members of the ship's company.

International Meteorological Conference.—The Council requested Mr. W. Ellis, F.R.S., to act as the delegate of the Society to the International Meteorological Conference, which was held at Paris, September 17 to 23. His Report on the Proceedings of the Conference was read at the meeting on November 18, and will appear in the *Quarterly Journal* in due course.

Stations.—Observations have been accepted from the following new stations:—The Priory, Hereford; Cromer; Ipswich; and Ryton-on-Tyne, Northumberland. The observations at Kenilworth and Strathfield Turgiss have been discontinued. Copies of detailed monthly returns, and annual summaries of results, have been supplied as usual to the Meteorological Office.

Inspection of Stations.—All the stations north of latitude 52° N., which had not been visited in 1895, have been inspected, and found on the whole to be in a satisfactory condition. Mr. Marriott's Report is given in Appendix II. p. 94.

Research Fund.—The Council regret that no donations to this fund have been received during the year. As the cost of the Wind Force Experiments is being charged on this fund, the Council trust that fresh donations may be forthcoming in 1897.

Library.—Considerable additions, by presentation and by purchase, have been made to the Library as well as to the collection of photographs and lantern slides. Of these a list will be found in Appendices IV. and V. pp. 106, 107.

Quarterly Journal.—This publication has contained several papers of considerable interest, more particularly those dealing with fog, wind velocity, cloud, and atmospheric dust.

Meteorological Record.—This publication has been brought up to June 1896, and is now in the sixteenth year of its existence.

Phenological Report.—This interesting and instructive Annual Report was, as usual, prepared by Mr. Mawley and read at the February Meeting. It is satisfactory to find that the number of observers has increased, and that the distribution of observing stations has been further improved.

Offices.—It is with deep regret that the Council have to announce that the Public Offices (Westminster) Site Act 1896, received Her Majesty's assent on August 7, 1896. The Council have not yet received any intimation of the date at which they will be required to vacate their rooms. In the meantime they have appointed a House Accommodation Committee to consider the acquisition of new premises, and they trust that satisfactory arrangements will eventually be made, whereby the Society may be enabled to secure rooms in the same neighbourhood.

Fellows.—The changes in the number of Fellows are exhibited in the following table, which shows an increase of seventeen during the year:—

FELLOWS.	ANNUAL.	LIFE.	HONORARY.	TOTAL.
1895, December 31	405	137	17	559
Since elected . . .	+ 38	+ 4	+ 1	+ 43
Deceased	− 11	...	− 1	− 12
Retired	− 14	...	...	− 14
1896, December 31	418	141	17	576

Deaths.—The Council have to announce with much regret the deaths of one Honorary Member and of eleven Fellows. The names are:—

Dr. Benjamin Apthorp Gould (Honorary Member)	elected	June 18, 1884.
Edward Balme Wheatley Balme	„	April 16, 1879.
Robert William Peregrine Birch, M.Inst.C.E., F.G.S.	„	Nov. 21, 1877.
Isaac Brown, F.R.A.S.	„	June 4, 1850.
Jabez Church, M.Inst.C.E., F.G.S.	„	Feb. 16, 1881.
John Langdon Haydon Langdon-Down, M.D., F.R.C.P.	„	March 16, 1892.
Rev. William Clement Ley, M.A.	„	Jan. 15, 1873.
Edward Lavington Oxenham, F.R.G.S.	„	Nov. 21, 1888.
Charles Burgess Nicholas Pearson	„	Nov. 28, 1854.
George Shaw	„	Dec. 19, 1894.
James Henry Steward	„	June 17, 1874.
Edward Owen Tudor, F.S.A.	„	June 4, 1850.

APPEN-

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

Balance from 1895				£102	3	3
Subscriptions for 1896	£699	9	0			
Do. former years	38	0	0			
Do. paid in advance	44	0	0			
Life Compositions	84	0	0			
Entrance Fees	40	1	0			
				905	10	0
Meteorological Office—Copies of Returns	£77	10	0			
Do. Grant towards Inspection Expenses	25	0	0			
				102	10	0
Dividends on Stock (including £40 : 14 : 10 from New Premises Fund)				119	11	8
Sale of Publications, &c.				33	6	3
				£1263	1	2

DIX I.

FOR THE YEAR ENDING DECEMBER 31, 1896.

EXPENDITURE.

Journal, &c.—		
Printing Nos. 97 to 100	£139 13 0	
Illustrations	27 5 2	
Authors' Copies	12 15 6	
Meteorological Record, Nos. 59 to 62	50 1 3	
Registrar-General's Reports	8 8 0	
		£238 2 11
Printing, &c.—		
General Printing	£15 6 6	
Forms	6 2 0	
List of Fellows	9 12 6	
Stationery	11 1 6	
Books and Book-Binding	18 11 8	
		60 14 2
Office Expenses—		
Salaries	£403 13 9	
Donation to Mrs. Horstman	25 0 0	
Rent and Housekeeper	200 0 0	
Repairs, Coals, &c.	18 0 8	
Postage	59 3 0	
Petty Expenses	9 15 6	
Refreshments at Meetings	13 19 6	
Lecture Expenses	10 10 0	
		740 2 5
Observations—		
Inspection of Stations	£48 4 4	
Observers	9 2 0	
Instruments	33 10 2	
		90 16 6
		£1129 16 0
Balance—		
At Bank of England	£129 5 3	
In hands of Assistant-Secretary	3 19 11	
		133 5 2
		£1263 1 2

Examined, compared with the Vouchers, and found correct,

FRED^C. GASTER, } *Auditors.*
M. JACKSON, }

January 13, 1897.

APPENDIX

ASSETS AND LIABILITIES

LIABILITIES.

To Subscriptions paid in advance	£44 0 0
,, Excess of Assets over Liabilities[1]	3220 8 5
	£3264 8 5

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[1] This excess is exclusive of the value of the Library and Stock of Publications.

WM. MARRIOTT, *Assistant-Secretary.*

NEW PREMISES FUND,

Amount paid to the Society's Funds towards the increased rent of the New Premises	£40 14 10

RESEARCH FUND,

Amount invested in the purchase of £2 : 16 : 9, 2¾ per cent Consols	£3 2 11

I.—Continued.

ON JANUARY 1, 1897.

ASSETS.

By Investment in M. S. and L. R. 4½ per cent Debenture Stock, £800 at 160	£1280	0	0			
,, Investment in N. S. W. 4 per cent Inscribed Stock, £654 : 18s. at 117	766	4	8			
,, Investment in L. & N. W. R. Ordinary Stock, £200 at 204	408	0	0			
,, Investment in 2½ per cent Annuities, £231 : 11 : 9 at 105½	244	6	6	£2698	11	2
,, Subscriptions unpaid, estimated at	£60	0	0			
,, Entrance Fees unpaid	8	0	0			
,, Interest due on Stock	51	18	5	119	18	5
,, Furniture, Fittings, &c.	£195	3	9			
,, Instruments	117	9	11	312	13	8
,, Cash at Bank of England	£129	5	3			
,, Cash in hands of the Assistant-Secretary	3	19	11	133	5	2
				£3264	8	5

Examined, and certificates of the above securities inspected, at the Bank of England.

FREDc. GASTER, } *Auditors.*
M. JACKSON, }

January 13, 1897.

DECEMBER 31, 1896.

Interest received on investment	£40 14 10

Note.—The Society holds on account of this Fund £1209 : 4 : 10 South Australian 3½ per cent Inscribed Stock.

Examined, and certificates of the above security inspected, at the Bank of England.

FREDc. GASTER, } *Auditors.*
M. JACKSON, }

January 13, 1897.

DECEMBER 31, 1896.

Interest received on investment	£3 2 11

Note.—The Society holds on account of this Fund £118 : 7 : 4, 2¾ per cent Consols.

Examined, and certificates of the above security inspected, at the Bank of England.

FREDc. GASTER, } *Auditors.*
M. JACKSON, }

January 13, 1897.

APPENDIX II.

INSPECTION OF STATIONS, 1896.

During this year I have visited all the stations north of lat. 52° N., and east of long. 2° W., which were not inspected last year. The stations were, on the whole, in a satisfactory condition.

The number of thermometers tested was 166; the zeros of 19 were found to have changed since the last testing.

It has been necessary to impress upon several of the observers the importance of paying greater attention to the wet bulb thermometer, especially during frost.

The returns from Sutton Coldfield had for some time past been very unsatisfactory and irregular. The maximum was sometimes lower, and the minimum higher, than the dry bulb reading. On investigation I found that the observations up to date were practically worthless, for the rain gauge had evidently not been examined daily, nor had the sunshine cards been regularly changed.

At two or three stations where a change of observer had taken place within the last few months, I found that the new observers had not been thoroughly trained. It is always desirable, where possible, that before any change is made, the new observer should be fully instructed in the methods of observation.

At a few of the stations there appears to be a difficulty in maintaining a good exposure for the sunshine recorders owing to the growth of trees and shrubs.

WILLIAM MARRIOTT.

October 1896.

NOTES ON THE STATIONS.

APPLEBY, *July* 13.—On comparing the thermometers it was found that the dry and wet had gone up 0°·2, and that the minimum had gone down 0°·7. The screen required strengthening to prevent vibration. I requested that some carnations which were growing close to the rain gauge should be set farther back.

BELMONT, *August* 12.—This station is at St. Michael's Priory, 2½ miles south-west of Hereford. The exposure is good. I recommended a rearrangement of the thermometers in the screen.

BELPER, *August* 20.—On comparing the thermometers it was found that the dry and wet had gone up 0°·1. The thermometer screen required painting.

BERKHAMSTED, *July* 29.—This station was in good order. The sunshine recorder required a little readjustment.

BLACKPOOL, *July* 9.—On comparing the thermometers it was found that the minimum had gone down 0°·3, and that the earth thermometer had gone up 0°·2. The sunshine recorder required readjustment. The inspection was greatly interfered with by a heavy thunderstorm, more than an inch of rain falling in less than four hours.

Bowness, *July* 10.—The Jordan sunshine recorder is on the roof of the Hydropathic Hotel. During the winter months it is removed to the roof of a tower. The exposure is good. The observer has a tendency to overstate the amount of sunshine.

Burghill, *August* 12.—Dr. Chapman having retired and left the asylum, Dr. Morrison, his successor, undertook to carry on the observations. I called on Dr. Morrison and gave him instruction in the method of taking and reducing the observations.

Burton-on-Trent, *August* 17.—At the time of my visit the observer was away for his holiday, and the deputy observer had also been summoned away that morning. I called again at the deputy's house on the 21st, but was unable to see him, consequently I could not inspect the station.

Buxton, *August* 19.—There was no change in the thermometers. The rim of the funnel of the rain gauge required soldering. The sunshine recorder was not fixed, and was not in time adjustment. I recommended that for the future it be firmly fixed.

Cheadle, *August* 18.—The instruments at this station were in good order.

Corton, *September* 4.—This station is on the cliff about two miles north of Lowestoft. The exposure of the thermometers and rain gauge is very good. The sunshine recorder is at the southern end of the grounds. I recommended that it should be raised considerably, so as to be free from the influence of some trees to the west-north-west.

Derby, *August* 20.—This station is at the Derbyshire Royal Infirmary. The thermometer screen was in the grounds at the back of the infirmary. It was in the shade from trees in the afternoon; it was also close to a gravel road on the south, and was consequently likely to be affected by reflected heat. I recommended that a more suitable situation should be obtained.

Driffield, *July* 22.—The observations at this station are continued by Mr. W. E. Lovel. The instruments were in good order. The muslin and cotton on the wet bulb are not changed very frequently.

Ely, *September* 2.—The instruments are placed in the kitchen garden of the Bishop's Palace. The thermometers required rearranging in the screen. On comparing the thermometers it was found that the wet bulb had gone up 0°·1.

Geldeston, *September* 5.—The Campbell-Stokes and the Jordan sunshine recorders are exposed on the ridge of a barn. They have a very good exposure. A tree, however, on the east subtends an angle of 12°, and a stack of chimneys on the south-south-east an angle of 14°.

Harrogate, *July* 20.—This station was in good order. Mr. Farrah has a duplicate set of thermometers ready for use in case of breakage. I suggested that the duplicate rain gauge should be measured monthly. A Campbell-Stokes sunshine recorder had recently been obtained. The trace, however, was not quite parallel with the card.

HILLINGTON, *September* 1.—The thermometer screen had been improved since the last inspection. The ball of the sunshine recorder was not quite in the centre of the frame. Mr. Ffolkes was away at the time of my visit, but the gardener appeared to take the observations very well.

HODSOCK, *August* 24.—This station was in good order. The trees on the east of the sunshine recorder may possibly intercept a little of the early morning sunshine.

KENILWORTH, *August* 14.—The thermometer screen required painting. The tube of the maximum had slipped about 2° ; this I readjusted. On comparing the thermometers it was found that the dry and wet had gone up 0°·1. I recommended that the rain gauge be moved about 18 feet west-north-west.

LANCASTER, *July* 10.—The thermometer screen was in the same position as at the last inspection. The thermometers were in good order; they are, however, only read to halves and quarters of a degree. The ball of the sunshine recorder was not quite in the centre of the frame, but I did not attempt to readjust it as the instrument is of the universal pattern. The Beckley self-recording rain gauge was not working properly, there being too much friction to allow the pencil to move freely. I altered the pencil, which eased it somewhat, but the instrument requires readjustment.

LINCOLN, *August* 26.—The minimum had 0°·5 of spirit at the top of the tube. The thermometer screen required painting. The electrical thermometer, together with the battery and galvanometer, at the Cathedral, appeared to be in good order. The thermometer screen on the tower required painting.

LOWESTOFT, *September* 4.—On comparing the thermometers it was found that the wet had gone up 0°·2. The 1-foot and 2-feet earth thermometers have long tubes surrounded by wooden or metal cases. I had not previously been able to test these thermometers, but on this occasion, with the assistance of Mr. Miller, I succeeded in doing so. I found that the 1-foot thermometer had slipped down its case about 3°, and was consequently reading much too low. The 2-feet thermometer was fully 1° too high.

MACCLESFIELD, *August* 19.—The minimum had 1° of spirit at the top of the tube. On comparing the thermometers it was found that the dry had gone up 0°·1.

RAVENSTHORPE, *August* 14.—A Stevenson thermometer screen had been set up since the previous inspection. The legs, however, required strengthening. I readjusted the thermometers in the screen.

ROTHBURY, *July* 17.—The thermometer screen had been moved since the last inspection to a less conspicuous site, about 10 feet lower than the previous one. On comparing the thermometers it was found that the dry had gone up 0°·1.

ROUNTON, *July* 20.—The earth thermometer had about 0°·3 of mercury up the tube. The index of the maximum thermometer was only about 5° in length, the air bubble evidently working out. The thermometer screen required painting.

SCALEBY, *July* 14.—There was no change in the thermometers. The screen required strengthening to prevent vibration. I gave the observer instructions as to the proper working of the wet bulb.

SCARBOROUGH, *July* 21.—The observations are now taken by Mr. Ellerbeck for the Medical Officer of Health. The instruments are placed on a small grass plot on the western side of the house. They are considerably sheltered on the east and south-east. A more satisfactory exposure is very desirable. I visited two or three suggested sites, and think it probable that the instruments will shortly be removed to one of them, where there will be a good exposure.

SEATHWAITE, *July* 11.—The thermometers were in good condition. Fresh back plates and clips were put on the maximum thermometer.

SOMERLEYTON, *September* 3.—On comparing the thermometers it was found that the maximum had gone up 0°·2. The 1-foot earth thermometer was loose in its stick, and required a good deal of packing to make it secure.

SOUTHPORT, *July* 8.—This station is at the eastern end of Hesketh Park. The Stevenson screen is in a circular railed-off enclosure, the rain gauges, earth thermometers, etc., being in another enclosure. The Fernley screen is on a knoll close by. In this there is a set of thermometers and a Fortin barometer; whilst on the outside there is a Kew barometer, Richard barograph, wind dial, etc. On the top of the screen are Campbell-Stokes and Jordan sunshine recorders, Dines pressure-tube anemometer, Robinson anemometer, evaporation dish in a Stevenson screen, etc. The instruments were all in good order, and the observations appeared to be satisfactorily taken.

STRELLEY, *August* 21.—The instruments, which were removed from Southwell in 1895, are placed on the lawn in front of the house. The thermometer screen required painting. On comparing the thermometers it was found that the minimum had gone down 0°·2. The slab of the sunshine recorder was not level, and consequently the trace was not parallel with the card. It was subsequently found that the post on which the recorder was mounted was unsound, and Mr. Edge promised to have a new one put up.

SUTTON COLDFIELD, *August* 13.—I found that the observations had been taken in an unsatisfactory manner. The readings of the maximum and minimum did not agree with those of the dry bulb. The rain gauge was not examined daily, nor were the sunshine cards regularly changed. I hope the observations will be more satisfactory in future. On comparing the thermometers it was found that the dry and wet had gone up 0°·3. I recommended a rearrangement of the thermometers in the screen.

USHAW, *July* 18.—There was no change in the thermometers. The screen required painting. The rain gauge was much corroded and required renewing.

Wakefield, *August* 25.—The observations are taken by the warders of the prison infirmary. There had been a change in the staff of observers in the early part of the year. This accounted probably for the readings of the maximum and minimum thermometers not having been very satisfactory for some months past. I altered the position of the dry and wet bulbs in the screen.

Wryde, *August* 31.—On comparing the thermometers it was found that the minimum had gone down 0°·2. A large piece of muslin had been put on the wet bulb, the ends completely overhanging the bulb like an umbrella. I recommended that for the future a much smaller piece of muslin should be used. The tube of the maximum had slipped down somewhat; this I readjusted.

APPENDIX III.

OBITUARY NOTICES.

Robert William Peregrine Birch, the second son of Mr. Peregrine Birch of The Priory, Forest Row, Sussex, was born in London, September 25, 1845, and was educated at King's College, Strand. In 1864 he became a pupil of the late Mr. James Abernethy, under whom he was employed upon important works, and was for some time a member of the engineering staff constructing the Swansea Docks. On leaving Mr. Abernethy he became Resident Engineer on the Thetford and Walton Railway under Mr. J. S. Valentine. As a Student of the Institution of Civil Engineers he was awarded in 1870 a Miller Prize for a paper entitled "The Disposal of Town Sewage." In 1870-71 he designed and carried out the drainage of Walton-on-Thames on the separate system, then little known, disposing of the sewage upon the plan recommended by Dr. Frankland in the *Report of the Royal Commission upon the Pollution of Rivers*, known as the "intermittent downward filtration." This was one of the earliest applications of this method of sewage disposal, and was very successful; but as the small area of ground acquired by the sanitary authority for the purpose was surrounded by land suitable for broad irrigation, the tenant of which was willing to use the sewage, the original plan was abandoned for the less troublesome and more profitable one. From this time Mr. Birch, who had set up in business in Westminster, began to be known as an authority on sanitary matters, and was extensively employed as such. His name will be remembered as the joint-author, with the late William Haywood, of the great scheme for the sewerage of the Lower Thames Valley adopted by the Sewerage Board, and embodied in a Bill which was rejected, after a stubborn fight, in its second reading in the House of Commons.

The next important inquiry with which Mr. Birch was connected was that into the pollution of the Thames by the sewage of London. He was employed by the Corporation of the City, acting as the Port Sanitary Authority, together with Mr. James Mansergh and Mr. Baldwin Latham, to lay the case against the late Metropolitan Board of Works before the Royal Commission on Metropolitan Sewage Discharge, 1884-85. During the inquiry Mr. Birch did most valuable work, and may be said to have contributed largely to the establishment of the case against the Board set out in the Report of the Commission, which resulted in the chemical treatment of the sewage being effected before its discharge into the river. An important question arose during the inquiry, viz.—"How long does it take for the sewage discharged at Barking and Crossness to reach the sea?" This, of course, varies with the quantity of upland water passing down the river, and Mr. Birch arrived at a solution of the question, which is explained in a paper he contributed to the Institution of Civil Engineers on "The Passage of Upland Water through a Tidal Estuary." This was read on May 20, 1884, and was followed by another contribution entitled "The Effect of the Drought of 1884 upon the Pollution of the River Thames below London."

Mr. Birch frequently acted for the London Water Companies in their struggles with the London County Council, and gave evidence for them on several occasions, notably before Lord Balfour's Commission of 1893, when he expressed the opinion, which he held very strongly, that it was unnecessary to look beyond the present sources for the water supply of London. He believed that with efficient works of storage, and the prevention of the present waste of water, the needs of London could be amply supplied by the existing companies. This view was adopted by the Commissioners in their Report.

While Mr. Birch was best known as a hydraulic and sanitary engineer, he was by no means exclusively employed in these branches of the profession. He was, with Mr. John Wolfe Barry and Mr. Brunel, engineer to the Guildford, Kingston, and London Railway, for which an Act was obtained in 1881, the section from Guildford to Kingston being now constructed. In conjunction with Prof. Henry Robinson, he was engineer to the Wimbledon and Putney Railway, for which an Act was obtained in 1882. He also had recently made an important extension of the pier at West Brighton.

Mr. Birch died in his fifty-first year from erysipelas of the face, after six days' illness, at Foyers, Loch Ness, while on a professional visit to the water-power works he was carrying out for the British Aluminium Company. An important portion of the works, viz. the tunnel-power works and factory, were successfully completed in June 1896, and are now in active operation. Mr. Birch was a man whose high character and kindly nature endeared him to every one with whom he was brought in contact. He was cut off in the plenitude of his powers, when his talents and devotion to his work were rapidly carrying him to a commanding position in the profession.

He was a Member of the Institution of Civil Engineers, and a Fellow of the Sanitary Institute.

Mr. Birch was elected a Fellow of this Society on November 21, 1877, and was a Vice-President at the time of his death.

JABEZ CHURCH, born at Chelmsford in 1845, was the son and grandson of well-known engineers bearing the same name. After being privately educated he was articled to his father, who had gained considerable reputation as a gas and water engineer. In 1867 he became a Student of the Institution of Civil Engineers, being one of the first candidates admitted into that class. Two years later he was taken into partnership by his father, and on the death of the latter in 1875 he continued the practice alone.

Among the works which Mr. Church designed and constructed, or for which he was professionally engaged, may be mentioned the gasworks at Barking, Barnet, Braintree, Brentwood, Colney Hatch, Cromer, Enfield, Epping, Harwich, Horley, Ilford, Saffron Walden, Thetford, Woking; also the Dublin Consumers' Gas Company's works; and the waterworks at Barnet, Barton-on-Humber, Clacton-on-Sea, Godalming, Goring, Great Marlow, Henley-on-Thames, the Mid-Sussex works, and the Witham water and drainage undertakings. Mr. Church also designed and carried out extensions of the works for the water-supply of Braintree and of Halstead, and those now in course of construction at Gainsborough were likewise designed by him.

Mr. Church died at his residence, 17 Holland Park Gardens, Kensington, on March 20, 1896, death being due to congestion of the lungs and heart disease. He was a Member of the Institution of Civil Engineers and a Fellow of the Geological Society, and was for two years in succession (1882 and 1883) President of the Society of Engineers. Upright and honourable in all his dealings, he was deservedly esteemed both professionally and privately.

He was elected a Fellow of this Society on February 16, 1881.

BENJAMIN APTHORP GOULD was born in Boston, U.S., September 27, 1824. He entered the Boston Latin School in 1836, and graduated from Harvard College, with high distinction in classical, as well as in mathematical and physical studies, in 1844. After teaching for a year in the Latin School, he decided to devote himself to a purely scientific career. As a preparation for this he went to Europe in July 1845 to study astronomy, working at the Greenwich Observatory three months, at the Paris Observatory four months, at the Berlin Observatory a year, at Göttingen Observatory a year, at Altona Observatory four months, and at Gotha Observatory one month. He returned home in 1848. In 1852 he was appointed to take charge of the longitude determinations of the Coast Survey. He organised, developed, and extended this service, retiring in 1867. Meanwhile in 1855, he became Director of the Dudley Observatory in Albany, equipped and organised the institution, and carried it on without remuneration and at his private expense. He left it in 1859, after a severe struggle to preserve the institution for purposes of scientific investigation.

In 1859 he published his discussion of the places and proper motions of circumpolar stars for use as standards in the Coast Survey. These, as revised by him in 1861, together with his similar list of clock-stars, were adopted as the standards for the American ephemeris, and, as to the circumpolars, remain in such use to this day. In 1866 he published his reduction of D'Agelet's observations. About the same time he performed a similar service for the greater part of the observations made at the United States Naval Observatory since its establishment, and also for the expedition to Chili to determine the solar parallax. In 1866 he planned and executed the work of establishing, by the Atlantic cable, the relation in longitude between European and American stations. As actuary of the United States Sanitary Commission, he conducted, and published in a large volume, extensive and important researches upon Military and Anthropological Statistics and the Distribution of Population. About the same time he undertook the reduction of Rutherford's photographs of the *Pleiades*. The results, partially published in 1866, were submitted completely, in an elaborate memoir, to the National Academy in 1870, together with a second memoir on the *Præsepe*. He was, indeed, a pioneer in the utilisation of photography for exact astronomical measurement. About 1864 he built an observatory in Cambridge, Mass., equipped with an 8-ft. transit instrument, and, until 1867, carried on a determination of the right ascensions of all the stars to the tenth magnitude within one degree of the Pole. This work was completely reduced, but the discussion and publication were postponed owing to his removal to Cordoba.

In 1865 he became intensely impressed with a desire to explore the southern celestial hemisphere. The opportunity to do so soon came. This project assumed at first the form of a private astronomical expedition, for which his friends in Boston had promised the pecuniary means; but, under the enthusiastic support of Mr. Sarmiento, at first as Argentine Minister to the United States, and later as President of that Republic, it rapidly broadened, and finally led to the establishment by Dr. Gould of a permanent National Observatory at Cordoba. This important addition to the observatories of the southern hemisphere, which are comparatively so few, forms an impressive monument to his memory.

It is impossible, in brief space, to describe or characterise the marvellous work here undertaken and so faultlessly pushed to completion by Dr. Gould, during the fifteen years of self-imposed exile from his native land, with unfaltering devotion and energy, in the face of difficulty and domestic bereavement. The work on the uranography of the southern heavens was finished in 1874, and was published under the title of the *Uranometria Argentina*, which will remain a classic for all time. For this work he received the Gold Medal of the Royal Astronomical Society in 1883. The zone observations of the stars between 23° and 80° south declination, which were the original and always the dominant object of the enterprise, were begun in 1872, substantially completed in 1877, and revised in 1882-83. This work was embodied in the Zone Catalogues, containing 73,160 stars, which appeared in 1884. Parallel with this, and almost overshadowing it in importance, was carried on the independent series of meridian-circle observations for the General Catalogue of 32,448 stars, completed in 1885.

Another part of the work for the Cordoba Observatory, planned by Dr. Gould as a fitting extension of it, was a *Durchmusterung* of the southern sky.

Dr. Gould also established under the auspices of the Argentine Government, a Meteorological Service, which has done very good work. Upon leaving South America he entrusted this charge to the hands of his worthy successor, Walter G. Davis.

Dr. Gould was one of the earliest to recognise the capabilities of photography to render service of precision to astronomy. At Cordoba he secured about 1400 plates showing photographs of southern stellar clusters. The principal occupation of the last ten years of his life was the measurement and reduction of these.

The establishment of the *Astronomical Journal* is not the least of the services rendered to the science by Dr. Gould. Feeling this to be one of the wants of astronomy, in 1849, he began that Journal as a medium for the publication exclusively of original investigations. He edited the Journal until at the end of the sixth volume in 1861, its issue was interrupted first by the war for the preservation of the Union, and afterwards by his absence in Cordoba. In 1885 he resumed its publication, which he continued until his death in November 1896.

He was elected an Honorary Member of this Society June 18, 1884.

JOHN L. H. LANGDON-DOWN, M.D., F.R.C.P., was born at Tor Point, Cornwall, in November 1828. He left school at the age of thirteen and a half to assist his father, who was an apothecary. His spare time was devoted to the reading of instructive books. In 1847 he entered as a student at the Pharmaceutical Society, London, was a prizeman, passed the examinations of the Society, and in 1849 became Assistant to Prof. Redwood, and assisted Faraday in some of his investigations on the diamagnetism of gases. He was urgently summoned home to Tor Point, however, and had to resign his post in London, but on the death of his father in 1853 he joined the London Hospital, being then nearly twenty-five years of age.

As a student at the hospital he was remarkable for diligence and scholarly ability. He became Prizeman in Chemistry in 1854; in 1856 he obtained the exhibition and gold medal in Materia Medica and Pharmaceutical Chemistry at the examination for honours at the Intermediate Examination in Medicine of the University of London, and honours in Structural and Physiological Botany at the same time. In 1858 he gained a gold medal in Physiology and Comparative Anatomy at the M.B. Examination, standing second to Dr. (now Sir) William Broadbent, who gained the exhibition and gold medal.

He became Resident Physician and Superintendent of Earlswood Asylum in 1858, and was elected Assistant Physician to the London Hospital on December 23, 1859, a month after the election of Mr. Jonathan Hutchinson as Assistant Surgeon. He was Medical Tutor at the London Hospital previously to his election as Assistant Physician. He then became Lecturer on Materia Medica and Therapeutics at the London Hospital Medical College, and afterwards Lecturer on the Principles and Practice of Medicine. He in turn became Physician and Senior Physician to the hospital, and Consulting Physician in 1890, on his retirement from the active staff.

Dr. Langdon-Down was remarkable for executive power and energy. For nine years after his election as Assistant Physician he continued to reside at the Earlswood Asylum, and his humane instincts, his zeal, and powers of organisation caused this institution to become foremost among those which trained weak-minded children to a fuller use of their faculties.

He was one of the founders of the New Sydenham Society, and almost through life he was on its Council and regularly attended its meetings. In 1887 he delivered the Lettsomian Lectures of the Medical Society, "On some of the Mental Affections of Childhood and Youth."

Dr. Langdon-Down was largely instrumental in founding the Thames Valley Branch of the British Medical Association, of which he was the first President; and he was for many years a member of the Council of the Association. In 1884 he was appointed Justice of the Peace for Westminster and Middlesex, and in 1889 was elected a County Alderman of Middlesex.

As a colleague he was beloved by all with whom he was associated. Living up to the highest principles himself, his influence over young and old was powerful for good. Yet he was no ascetic, and acted on occasions as a most genial host. The pleasant reunions at Normansfield will be long remembered, especially that of the International Medical Congress, 1881, the Congress of Hygiene and Demography in 1891, and the British Medical Association during the London meeting of 1895. Normansfield is a home founded by Dr. Langdon-Down in 1868, for the care and training of the feeble-minded of the upper classes, for whom there was then no suitable provision. Success followed this project, and the original building has been enlarged on several occasions. It now accommodates 200 patients.

Dr. Langdon-Down had not enjoyed good health since 1890, when he had a severe attack of influenza. On October 7 he was on his way to the breakfast table at Normansfield, Hampton Wick, when he became unconscious and fell, and in less than ten minutes died.

He was elected a Fellow of this Society on March 16, 1892.

REV. WILLIAM CLEMENT LEY, who died suddenly, April 22, 1896, was the son of the late William Henry Ley, at one time headmaster of the Hereford Cathedral School, and subsequently, for forty years, vicar of Sellack with King's Capel, Herefordshire. His mother was the daughter of Dr. J. C. Prichard, F.R.S., who is best known as the author of *Researches into the Physical History of Mankind*, a work, of which the third edition, issued in 1847, consisted of five volumes.

Clement Ley was born in Bristol July 6, 1840. He was educated by his father and secured a classical Demyship at Magdalen College, Oxford, in 1857. He obtained First Class in Moderations and graduated B.A. 1862, and M.A. 1864. He was ordained in 1863, and after being curate at King's Capel and subsequently at Breinton, both in Herefordshire, he was, in 1874, presented by the Lord Chancellor to the living of Ashby Parva in Leicestershire, which he resigned in 1892, owing to ill-health.

He married, in 1866, Elizabeth Crockett, daughter of Admiral William Hillyar. She died in 1894, leaving a family of eight children, several of whom have already shown good promise of distinction.

Mr. Ley was elected a Fellow of this Society on January 15, 1873, and in 1879 was appointed by the Meteorological Council their Inspector of stations for England, an office which he held till his decease.

Mr. Ley's principal scientific publications were:—*The Laws of the Winds prevailing in Western Europe*, 8vo, 1872.—*Aids to the Study and Forecast of Weather*, published by the authority of the Meteorological

Council, 1880.—*Cloudland*, 8vo, 1894. This last work was finally completed for press by his third son, Lieut. Cuthbert Ley, R.E., during his father's illness.

Mr. Ley published numerous papers in the Journal of this Society, and in that of the Scottish Meteorological Society. Among the chief of those were:—"Results of an inquiry into the inclination of winds towards the lower isobars" (*Journal Scottish Meteorological Society*, vol. iv. 1876).—"The relation between the upper and under currents of the atmosphere around areas of barometrical depression" (*Quarterly Journal*, vol. iii. 1877).—"On the structure of *cirro-filum* or ice-cloud disposed in threads" (*Quarterly Journal*, vol. ix. 1883).

Clement Ley was a scientific meteorologist in the highest sense, and as an authority on all matters pertaining to clouds he was second to none. In his works on the *Laws of the Winds*, his studies of clouds, and the laws which govern the movement of the upper current, he displayed a keen insight into the workings of Nature. In the lecture on "Clouds and Weather-signs,"[1] which he delivered before the Society in 1878, he said, "My own earliest recollections are those of looking at the clouds, and forming infantine speculations as to the causes of their forms and movements, and of being reprehended for exposing myself to all states of weather for this purpose. The tendency was inveterate, and to this day I have spent nearly a twelfth part of my waking existence in that occupation." His family are in possession of some of his early efforts at cloud pictures and weather charts.

He was particularly devoted to the study of thunderstorms, which he had a wonderful power of forecasting; and when storms came on at night, he was always to be found watching them.

In that part of Leicestershire where he lived for so many years, his weather forecasts were celebrated. During the hay and corn harvests, he was in the habit of putting up outside his Rectory gates his prognostication for the ensuing twenty-four hours, and early in the morning the farmers would ride from neighbouring villages to consult these forecasts, and the exact date of cutting hay or corn depended on the opinion there expressed.

If Luke Howard may be considered as the founder of cloud nomenclature, Clement Ley may be considered an eminent scientific classifier. No system yet brought forward is so complete as his, and, though various meteorologists take exception to the number of divisions into which he divides clouds, yet there can be little objection to the logical foundation on which he seeks to build up his system.

Clement Ley was of a kind and genial nature, but his long-continued ill-health acting on a nature naturally nervous, obliged him to keep very quiet, and often prevented that intercourse with friends which was much desired by all who had the privilege of knowing him. His loss is much felt by many who had the pleasure of being personal friends, and a still larger number of scientific men who felt that in Clement Ley there was a man who could gather up facts, and out of them formulate a theory of meteorology which would at once place its study on a more satisfactory basis than at present.

He suffered from pulmonary affections during the later years of his life, and his enthusiasm for weather study made him disregard the most obvious measures of precaution in exposing himself to the elements.

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[1] *Modern Meteorology*, 1879, p. 104.

He leaves a gap in our ranks, which will hardly ever be filled.

EDWARD LAVINGTON OXENHAM, F.R.G.S., was the son of the late Rev. W. Oxenham of Harrow School. He was appointed a student interpreter in China in July 1866, and, having risen through the usual grades to be first-class assistant, became acting interpreter at Kiukiang in 1870. From that time on till 1878 he occupied a similar post at different Chinese stations. Then, in 1878, he was Acting Consul at Wuhu, and two years later was promoted to be Consul at Chinkiang.

Mr. Oxenham acted as United States Consul in 1880 and 1881, and was also Consul for other foreign Powers at different times. He was called to the Bar at the Middle Temple in 1883. In 1888 he was transferred to Kiungchow, and in 1890 to Ichang. At the end of the latter year he retired on a pension.

He died at Bognor, September 26, 1896.

He was elected a Fellow of this Society on November 21, 1888.

CHARLES BURGESS NICHOLAS PEARSON, who was born on May 31, 1834, was the son of the Rev. Charles Buchanan Pearson, Prebendary of Salisbury and Rector of Knebworth, Herts. His grandfather was the Very Rev. Hugh Nicholas Pearson, Dean of Salisbury. He was educated at Eton and at Trinity College, Cambridge. He had a great talent for music, and became a consummate pianist. Quite as a youth he developed a remarkable taste for meteorology, which he retained to the end of his life.

In 1867 Mr. Pearson entered at the Inner Temple, and in 1870 was called to the Bar. He then proceeded to India, where he practised at Mozufferpore, Tirhoot, Bengal, down to March 1885, when failing health compelled him to retire.

He communicated to this Society several papers "on the Meteorology of Mozufferpore," containing the results of his observations from 1875 to 1879. These were printed in the *Quarterly Journal*, vols. iii.-vi.

After his return from India he resided at Reading, where he made meteorological observations with the greatest regularity. For several years he suffered from a painful malady, which he bore with great fortitude and resignation. He died on November 22, 1896.

He was elected a Fellow of this Society November 28, 1854.

GEORGE SHAW was born at Dalkeith in 1822, and came to London at the age of eighteen. In 1854 he entered into business on his own account, and for forty-one years he carried on business as a builder, decorator, and plumber at 20 King Edward Street, City. He took an active part in the public work of the Corporation of London. In 1883 he was chairman of the City Commission of Sewers, and in 1885 chairman of the Library Commissioners. He was twice chairman of the City Lands Committee, and occupied the chair of several other committees, and at his instance the Corporation commissioned Dr. Reginald Sharpe to write the work entitled *London and the Kingdom*. At the time of his death he was serving on the Bridge House Estates Committee, the Commission of Sewers, the City of London Schools Committee, and the Library Committee.

Mr. Shaw was a prominent member and a former Master of the Plumbers' Company, and he was the originator of the scheme for the registration of plumbers. He presided at the Plumbers' Congress at the International Health Exhibition in 1884, and suggested and superintended the erection of the Old London Street at that Exhibition, which was carried out by Mr. G. R. Birch, the architect. He was also one of the representatives of the Corporation of London on the Council and Executive Committee of the City and Guilds of London Institute. Mr. Shaw was author of a book entitled *Revived Guild Action, with a History of the Movement for the Registration of Plumbers*, published in 1878, a second edition of which was published in 1889.

He died at Dover on August 14, 1896.

He was elected a Fellow of this Society on December 19, 1894.

EDWARD OWEN TUDOR was born on February 9, 1827, and was the eldest son of Mr. Henry Tudor. After leaving school he entered his father's office in Threadneedle Street as a stockbroker, and became a member of the Stock Exchange. He joined his father in the business, which was then carried on as Henry Tudor and Son.

He led a very quiet life, delighting mostly in the lectures at the Royal Institution.

He was a Fellow of the Royal Geographical Society and of the Society of Antiquaries. He was also a member of the Conservative Club.

He died on November 20, 1896.

Mr. Tudor was one of the original Members of this Society, having been elected on June 4, 1850.

APPENDIX IV.

BOOKS, ETC., PURCHASED DURING THE YEAR 1896.

COTTE, P.—Mémoires sur la météorologie, pour servir de suite et de supplément au Traité de Météorologie publié en 1774. 2 vols. 4° (1788).

HELLMANN, G.—Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus: No. 5. Die Bauern-Praktik, 1508. Facsimiledruck mit einer Einleitung (1896). No. 6. George Hadley, Concerning the Cause of the General Trade-Winds. London, 1735. Facsimiledruck mit einer Einleitung. 4° (1896).

M'LEOD, A.—Scripture Meteorology and Modern Science. 8° (1867).

PARIS, COMITÉ MÉTÉOROLOGIQUE INTERNATIONAL.—Atlas International des Nuages. 4° (1896).

YEAR-BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES of Great Britain and Ireland, 1896. 8° (1896).

PHOTOGRAPH.

INTERNATIONAL METEOROLOGICAL CONFERENCE, Paris, September 1896.

LANTERN SLIDES.

CLOUDS at Sydney, N.S.W., 1894 (6 slides).

INTERNATIONAL METEOROLOGICAL CONFERENCE, Paris, September 1896.

KEW OBSERVATORY, Richmond, Surrey.

MOUNTAIN OBSERVATORIES.—Mt. Washington, Pic du Midi, and Puy de Dôme (4 slides).

TURNER'S Representation of Lightning.

WEATHER CHARTS (2 slides).

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1896.

Presented by Societies, Institutions, etc.

Adelaide, Observatory.—Meteorological Observations made at the Adelaide Observatory and other places in South Australia and the Northern Territory, 1891-3.

Aix-la-Chapelle, Meteorologische Station.—Ergebnisse der meteorologischen Beobachtungen, Jahrgang I.

Allahabad, Meteorological Office.—Annual Statement of Rainfall in the North-West Provinces and Oudh, 1895.

Baltimore, Maryland State Weather Service.—The Climatology and Physical Features of Maryland.

Bangalore, Central Observatory.—Meteorological Results of Observations taken at the Bangalore, Mysore, Hassan and Chitaldroog Observatories, by J. Cook.

Barbados, Colonial Secretary's Office.—Returns of Rainfall in Barbados, 1896.

Batavia, Magnetical and Meteorological Observatory.—Observations, 1894.—Rainfall in the East Indian Archipelago, 1894.

Berlin, Deutsche Meteorologische Gesellschaft.—Berliner Zweigverein, 1896.

Berlin, Gesellschaft für Erdkunde.—Verhandlungen, Band xxii. No. 10 to Band xxiii. No. 8.—Zeitschrift, Band xxx. No. 6 to Band xxxi. No. 4.

Berlin, Königlich Preussisches Meteorologisches Institut.—Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung im Jahre 1895, Heft II.

Bermuda, General Register Office.—Report of the Registrar-General, 1895.

Bidston, Liverpool Observatory.—Report of the Director of the Observatory, 1895.

Bombay, Government Observatory.—Magnetical and Meteorological Observations, 1894-5.

Bombay, Meteorological Office.—Brief Sketch of the Meteorology of the Bombay Presidency for 1895-6.

Bremen, Meteorologische Station.—Ergebnisse der meteorologischen Beobachtungen im Jahre 1895, und in dem Lustrum 1891-5.

Brisbane, Chief Weather Bureau.—Observations at Meteorological Stations in Queensland, 1895.—Summaries of Rainfall in Queensland, 1895.

Brisbane, General Register Office.—Annual Report by the Registrar-General on the Vital Statistics of Queensland, 1895.—Report on the Vital Statistics, Oct. 1895 to Sept. 1896.

Brisbane, Royal Geographical Society of Australasia (Queensland Branch).—Proceedings and Transactions, vol. xi. 1895-6.

British New Guinea, Government Secretary's Office.—Meteorological Observations taken at Daru (Western Division), Jan. to June 1895.—Meteorological Observations taken at Port Moresby, July 1894 to Dec. 1895.

Brussels, Observatoire Royale de Belgique.—Annales, Observations météorologiques d'Uccle, Oct. 1893 to July 1894.—Annuaire, 1896.—Bulletin Météorologique, Dec. 1895 to Nov. 1896.

Bucharest, Institut Météorologique de Roumanie.—Annales, tomo x. 1894. Buletinul Observatiunilor Meteorologice din Romania, 1895.

Budapest, Königl. Ung. Central-Anstalt für Meteorologie und Erdmagnetismus.—Jahrbuch, 1893.

Budapest, Königl. Ung. naturwissenschaftliche Gesellschaft.—Erdmagnetische Messungen in der Ländern der Ungarischen Krone in der Jahren 1892-4.

Buenos Ayres, Oficina Meteorológica Argentina.—Annales, tomo x.

Calcutta, Department of Revenue and Agriculture of the Government of India.—Statistical Atlas of India, 1895.

Calcutta, Meteorological Department of the Government of India.—Daily Weather Charts of the Indian Monsoon Area, April 23, 1895, to May 30, 1896.—India Daily Weather Reports, Dec. 7, 1895, to Nov. 27, 1896.—Indian Meteorological Memoirs, vol. vi. parts ii. and iii., vol. vii. part v., vol. viii. part i., and vol. ix. parts i.-vii.—Memorandum on the Snowfall in the mountain districts bordering Northern India and the abnormal features of the weather in India during the past year, with a forecast of the probable character of the South-west Monsoon rains of 1896.—Monthly Weather Review, Aug. 1895 to May 1896.—Rainfall data of India, 1895.—Report on the Administration of the Meteorological Department of the Government of India, 1895-6.—Summary of meteorological conditions over the Punjab during Feb. 1896.

Calcutta, St. Xavier's College Observatory.—Meteorological Register kept at Xavier's College Observatory, Jan. 1868 to Mar. 1896.

Cambridge, U. S., Astronomical Observatory of Harvard College.—Observations made at the Blue Hill Meteorological Observatory, Mass., 1894.—Observations of the New England Weather Service, 1894.—Report of the Director for the year ending Sept. 30, 1895.

Cape Town, South African Philosophical Society.—Transactions, vol. viii. part ii.

Carlsruhe, Centralbureau für Meteorologie und Hydrographie im Grossherzogthum Baden.—Die Ergebnisse der meteorologischen Beobachtungen, 1895.—Niederschlagsbeobachtungen der meteorologischen Stationen im Grossherzogthum Baden, 1895, part ii. ; and 1896, part i.

Chemnitz, Königl. Sachisches meteorologisches Institut.—Das Klima des Königreiches Sächsen, Heft 3.—Jahrbuch, 1894, Halfte 2 ; and 1895, Halfte 1 and 2.—Vier Abhandlungen über Periodizität des Niederschlages, theoretische Meteorologie und Gewitter-regen, von Prof. Dr. P. Schreiber.

Christiania, Norske Meteorologiske Institut.—Jahrbuch, 1893-5.—Klima Tabeller for Norge : I Luftens Temperatur ; II Lufttryk ; Af H. Mohn.—Oversigt over Luftens Temperatur og Nedborden i Norge i Aaret 1895.

Constantinople, Observatoire Impérial Météorologique.—Bulletin Météorologique et Séismique, Dec. 1895 to April 1896.

Copenhagen, Danske Meteorologiske Institut.—Bulletin Météorologique du Nord, Dec. 1895 to Oct. 1896.—Meteorologisk Aarbog, 1894, part i. ; and 1895, parts i. and iii.—Meteorologiske Observationer I Kjøbenhavn, bearbejdede af V. Willaume-Jantzen, med et Résumé des Observations Météorologiques de Copenhague.

Cordoba, Academia Nacional de Ciencias.—Boletin tomo xiv., Entrega 3 and 4.

Cracow, K. K. Sternwarte.—Meteorologische Beobachtungen, Dec. 1895 to June 1896.

Croydon, Microscopical and Natural History Club.—Daily Rainfall in the Croydon District, Nov. 1895 to Nov. 1896.—Report of the Meteorological Sub-Committee, 1895.

Dublin, General Register Office.—Annual Report of the Registrar-General (Ireland), 1895.—Weekly Returns of Births and Deaths, 1896.

Dublin, Royal Irish Academy.—Proceedings, third series, vol. iii. Nos. 4 and 5.—Transactions, vol. xxx. parts xv.-xx.

Dublin, Royal Society.—Proceedings, vol. viii. parts iii. and iv.—Transactions, vol. v. part v. to vol. vi. part i.

Edinburgh, General Register Office.—Quarterly Returns of the Births, Marriages, and Deaths, registered in Scotland for the year ending September 30, 1896.

Edinburgh, Royal Scottish Geographical Society.—Scottish Geographical Magazine, 1896.

Edinburgh, Royal Society.—Proceedings, vol. xx.

Edinburgh, Scottish Meteorological Society.—Journal, third series, Nos. 11 and 12.

Falmouth, Royal Cornwall Polytechnic Society.—Annual Report, 1895.

Fiume, I. R. Accademia di Marina.—Meteorological Observations, July 1895 to June 1896.

Geneva, Société de Géographie.—Le Globe, tome xxxv.

Glasgow, Philosophical Society.—Proceedings, vol. xxvi. 1894-5.

Greenwich, Royal Observatory.—Magnetical and Meteorological Observations, 1893.—Reduction of Greenwich Meteorological Observations, part iii. : Temperature of the Air 1841-90.—Report of the Astronomer-Royal to the Board of Visitors, June 6, 1896.

Halle, Kaiserliche Leopoldino-Carolinische Deutsche Akademie der Naturforscher.—Der thermische Aufbau der Klimate, aus den Wärmewirkungen der Sonnenstrahlung und des Erdinneren, von Dr. W. Zenker.—Die magnetische Declination und ihre säxulare Veränderung für 48 Beobachtungsörter, von Dr. G. D. E. Weyer.—Leopoldina, 1894 - 5.—Versuch einer theoretischen Darstellung des täglichen Ganges der Lufttemperatur, von Dr. J. Halm.

Hamburg, Deutsche Seewarte.—Achzehnter Jahres Bericht über die Thätigkeit für das Jahr 1895.—Aus dem Archiv, 1895.—Bemerkungen und Vorschläge zum Programm für die internationale meteorologische Konferenz in Paris im September 1896.—Deutsche überseeische meteorologische Beobachtungen, Heft VII.—Ergebnisse der meteorologischen Beobachtungen an 10 Stationen II Ordnung und an 45 Signalstellen, sowie stündliche Aufzeichnungen an 2 Normal-Beobachtungens-Stationen, 1894.—Wetterbericht, 1896.—Wetterbericht, 21 June 1826.

Hongkong, Observatory.—China Coast Meteorological Register, 1895.—Extract of Meteorological Observations, Nov. 1895 to Oct. 1896.—Observations and Researches, 1895.

Jamaica, Government Meteorologist.—Jamaica Rainfall, 1894.—The Kingston Anemometer.—The Kingston Barograph.—Weather Report, Sept. 1895 to Aug. 1896.

Jurjew (Dorpat), Kaiserliche livländische gemeinnutzige und okonomische Sozietat.—Bericht über die Ergebnisse der Beobachtungen an den Regenstation 1895, nebst Mittelwerthen für die Lustren 1886-90 und 1891-5.

Jurjew (Dorpat), Meteorologisches Observatorium der kaiserlichen Universitat.—Appareil servant à démontrer les courbes périodiques.—Exponate des meteorologischen Observatoriums der kaiserlichen Universität in Jurjew (Dorpat) auf der Allrussischen Ausstellung 1896 in Nishnij-Nowgorod.—Meteorologische Beobachtungen, 1894.—Ueber starke Schwankungen des Luftdruck's im Jahre 1887, von B. Sresnewskji.

Kazan, Observatoire Magnetique de l'Université Imperiale.—Observations, Mar. to Aug. 1895.

Kew, Observatory.—Report of the Kew Committee, 1895.

Lansing, Michigan State Board of Health.—Annual Report, 1893.—Principal Meteorological conditions in Michigan, 1893.

Leon, Escuela de Instruccion Secundaria.—Resumen General de las Observaciones Meteorológicas, 1895.

Leon, Observatorio Meteorológico.—Boletin Mensual, Jan. to Nov. 1896.

Lisbon, Sociedade de Geographia.—Boletim, 14a serie, No. 4, to 15a serie, No. 4.

Liverpool, Literary and Philosophical Society.—Proceedings, vols. xliv.-l.

London, British Association for the Advancement of Science.—Report, 1895.

London, Camera Club.—Journal, 1896.

London, Colonial Office.—Annual Meteorological Report, Straits Settlements, 1895.

London, General Register Office.—Quarterly Returns of Marriages, Births, and Deaths for the year ending Sept. 30, 1896.—Weekly Returns of Births and Deaths, 1896.

London, Geological Society.—Quarterly Journal, vol. lii. 1896.

London, Institution of Electrical Engineers.—Journal, Nos. 119-124.

London, Institution of Junior Engineers.—Record of Transactions, vol. v. 1894-5.

London, Meteorological Office.—Daily Weather Reports, 1896.—Hourly Means at the five observatories under the Meteorological Council, 1892.—Monthly Current Charts for the Indian Ocean.—Report of the Meteorological Council for the year ending March 31, 1895.—Weekly Weather Reports, 1896.—Bulletin quotiden de l'Algerie, Dec. 1895 to Aug. 1896.—Cartes Synoptiques Journalières du Temps, embrassant le Nord de l'Atlantique et une partie des Continents avoisiants, vols. v., vi., viii., x., 1885-91.—Comparative Rainfall, Colony of the Gambia, 1895 and 1891-5.—Le vent dans les grains, par E. Durand-Gréville.—Magnetische Beobachtungen in der Schweiz in Jahre, 1895.—Meteorologische Beobachtungen zu Klagenfurt, 1892-5.—Papers and Proceedings of the Royal Society of Tasmania, 1894-5.—Report on the Meteorology of Ceylon, 1895.—Return of Rainfall in Ceylon during 1895, and means during different periods.—Weather Record for Honolulu and the Hawaiian Islands, 1893.—Wypadki Spostrzézén Meteorologicznych dokonanych wroku 1893, ka Stacyach Meteorologicznych urzadzonych staraniem Sekcyi Cukrowniezej Warszawskiego Oddzialu Towarzystwa Popierania Russkiego Przemyslu i Handlu.

London, Physical Society.—Proceedings, 1896.

London, Royal Agricultural Society.—Journal, third series, vol. vi. part iv. to vol. vii. part iii.

London, Royal Astronomical Society.—General Index to vols. xxx. to lii. of the Monthly Notices, 1869-92.—Monthly Notices, vol. lvi. No. 2 to vol. lvii. No. 1.

London, Royal Botanic Society.—Quarterly Record, Dec. 1895 to June 1896.

London, Royal Geographical Society.—Geographical Journal, 1896.

London, Royal Institution of Great Britain.—Proceedings, No. 89.

London, Royal Society.—Catalogue of Scientific Papers (1874-83), vol. xi.—Proceedings, Nos. 353 to 362.

London, Sanitary Institute.—Illustrated List of Exhibits to which Medals have been awarded.—Journal, vol. xvi. part iv. to vol. xvii. part iii.

London, Society of Arts.—Journal, 1896.

Madras, Observatory.—Daily Meteorological Means.

Madrid, Observatorio.—Observaciones Meteorológicas, 1894-5.—Resumen de las observaciones meteorológicas efectuadas en la Peninsula y algunas de sus Islas adyacentes, 1893-4.

Madrid, Sociedad Geographica.—Boletin, tomo xxxvii. No. 7 to tomo xxxviii. No. 6.—Geografía Descripción Universal de las Indias.

Magdeburg, Wetterwarte der Magdeburgischen Zeitung.—Jahrbuch der meteorologischen Beobachtungen, 1894.

Manchester, Literary and Philosophical Society.—Complete List of Members and Officers from its institution on Feb. 28, 1781, to April 28, 1896, etc.—Memoirs and Proceedings, fourth series, vol. x. part i. to vol. xi. part i.

Manila, Observatorio Meteorológico.—Boletin Mensual, 1895.

Marlborough, College Natural History Society.—Report, 1895.

Marseilles, Commission de Météorologie du Département des Bouches-du-Rhone.—Bulletin Annuel, 1893-4.

Mauritius, Royal Alfred Observatory.—Annual Report of the Director, 1893-4.—Results of meteorological observations, 1895.

Melbourne, Observatory.—Record of results of observations in meteorology, terrestrial magnetism, etc., 1895.

Mexico, Observatorio Meteorológico Magnetico Central.—Boletin Mensual, Oct. 1895 to Oct. 1896.

Mexico, Sociedad Cientifica "Antonio Alzate."—Memorias y Revista, tomo viii. Nos. 1 and 2, and tomo ix. Nos. 1-10.

Milan, R. Osservatorio Astronomico di Brera.—Osservazioni Meteorologiche, 1895.

Montevideo, Sociedad Meteorológico Uruguaya.—Resumen de las observaciones pluviométricas efectuadas en el tercer trimestre del año de 1895.

Moscow, Société Imperiale des Naturalistes.—Bulletin, 1895, No. 3, to 1896, No. 2.

Munich, K. B. Meteorologische Central-Station.—Beobachtungen der meteorologischen Stationen im Kön Bayern, Jahrgang XVII, Heft 3 to Jahrgang XVIII, Heft 2.—Uebersicht über die Witterungsverhaltnisse im Kön Bayern, Nov. 1895 to Oct. 1896.

Natal, Observatory.—Report of the Superintendent for the years 1894-5.

Newcastle-on-Tyne, The Federated Institution of Mining Engineers.—Report of the proceedings of the conference on inland navigation, Birmingham, Feb. 12, 1895.

New York, Central Park Observatory.—Abstracts of Registers from self-recording Instruments, Nov. 1895 to Oct. 1896.

Odessa, Observatoire Météorologique de l'Université Imperiale.—Annales, 1894-5, par A. Klossovsky.—Revue Météorologique, Travaux du réseau Météorologique du sud-ouest de la Russie, vol. vii. 1894 ; ditto, dix ans d'existence, 1886-95.

O-Gyalla, Meteorologisch-Magnetisches Central-Observatorium.—Beobachtungen, Nov. 1895 to Oct. 1896.

Ona (Spain), Colegio Maximo de la Compañia de Jesus.—Observaciones Meteorologicas, 1895.

Ottawa, Geological Survey of Canada.—Report, 1894.

Oxford, Radcliffe Observatory.—Results of Meteorological Observations, 1888-9.

Paris, Bureau Central Météorologique de France.—Annales 1893-4.—Bulletin International, 1896.—Bulletin Mensuel, Jan. to Sept. 1896.

Paris, Observatoire Municipal de Montsouris.—Annuaire, 1896.

Paris, Société Astronomique de France.—Bulletin et Revue Mensuelle d'Astronomie, de Météorologie et de Physique du Globe, Feb. to May 1896.

Paris, Société Météorologique de France.—Annuaire, Apr. to Dec. 1895.

Perpignan, Observatoire.—Bulletin Météorologique publié sous les auspices du département et de la ville de Perpignan, 1893-4.

Philadelphia, American Philosophical Society.—Proceedings, Nos. 148-151.—Transactions, vol. xviii. part iii.

Pola, K. K. Hydrographisches Amt.—Meteorologische Termin—Beobachtungen in Pola und Sebenica, Jan. to Oct. 1896.—Meteorologische und magnetische Beobachtungen, Oct. to Dec. 1895.

Port au Prince, Haiti, Observatory.—Meteorological Observations, 1895.

Prague, K. K. Sternwarte.—Magnetische und meteorologische Beobachtungen, 1895.

Puebla, Observatorio Meteorológico del Colegio del Estado.—Resumen correspondiente á cada dia, Feb. and Mar. 1896.

Quito, Observatorio Astronomico.—Boletin, Año I. Nos. 2 to 11.

Rio de Janeiro, Observatoire.—Annuario, 1896.—Determinação das Posiçoes Gegraphicas de Redeio, Entre-Rios, Juiz de Fóra, João Gomes e Barbacena, publicado por L. Cruls.—Méthode Graphique pour la Détermination des heures approchées des Eclipses du Soleil et des Occultations, par L. Cruls.

Rochester, N.Y., Academy of Science.—Proceedings, vol. ii. Brochure 3 to vol. iii. Brochure 1.

Rome, Societa Sismologica Italiana.—Bollettino, vol. i. No. 7 to vol. ii. No. 4.

Rome, Ufficio Central di Meteorologia e di Geodinamica.—Annali, serie seconda, vol. xiii. part ii.—Rivista Meteorico-Agraria, Anno XVI. No. 35 to Anno XVII. No. 34.

St. Petersburg, Physikalisches Central-Observatorium.—Annalen, Theil 1 and 2, 1894.—Cyclonenbahnen in Russland für die Jahre 1887-9. von B. Sresnewskji. —Die Bewölkung des Russischen Reiches, von A. Schoenrock.—Jahresbericht, 1894. —Magnetische Beobachtungen auf einer Reise nach Urga im Sommer 1893, nebst Bemerkungen über die Aenderungen der erdmagnetischen Elemente in Ost-Siberien, von Ed. Stelling.—Neue vieljährige und fünfjahrige Mittel der Niederschlagsmengen und der Zahl der Tage mit Niederschlag für das Russische Reich, von Dr. H. Wild. —Ueber die Richtung und Stärke der Winde im Russischen Reiche, von I. Kiernowsky.

Salonica, Gymnase Bulgare des Garçons "St. Cyrille et Method."—Bulletin Annuaire, 1895.

Saltillo, Mexico, Observatorio Meteorológico del Colegio de San Juan Nepomuceno.—Boletin Mensual, tome i. Nos. 4 to 9.—Observaciones Meteorológicas practicadas durante el año de 1895.

San José (Costa Rica), Instituto Fisco—Geografico y del Museo Nacional.—Annales, tome vi. 1893.

Sarajevo, Gouvernement pour la Bosnie et l'Herzegovine.—Ergebnisse der Meteorologischen Beobachtungen der Landesstation in Bosnien-Hercegovina, im Jahre 1894.

Sarzana, Osservatorio Meteorologico nel Seminario Vescovile.—Riassunto delle Osservazioni Meteorologische dal 1 Dicembre 1894 a tutto Novembre 1895, Anno 1.

Sophia (Bulgaria), Station Centrale Météorologique.—Bulletin mensuel, Dec. 1895 to Oct. 1896.

Southport, Meteorological Department.—Report and Results of Observations, 1895, by J. Baxendell.

Stockholm, Academie Royale des Sciences de Suède.—Iakttagelser under en Ballongfärd den 19 Oktober 1893, af S. A. Andrée.

Stockholm, Meteorologiska Central-Anstalten.—Månadsöfversigt af Vaderleken i Sverige, Nov. 1895 to Oct. 1896.—Meteorologiska Iakttagelser i Sverige, 1891.

Stonyhurst, College Observatory.—Results of Meteorological and Magnetical Observations, 1895.

Strassburg, Meteorologisches Landesdienst in Elsass-Löthringen.—Ergebnisse der meteorologischen Beobachtungen im Reichslande Elsass-Löthringen, 1894.

Sydney, Observatory.—Daily Weather Charts, 1895.—Meteorological Observations, Mar. to Dec. 1895.—Results of Rain, River, and Evaporation Observations, made in New South Wales, 1894.

Sydney, Royal Society of New South Wales.—Journal and Proceedings, vol. xxix. 1895.

Tacubaya (Mexico), Observatorio Astronómico Nacional.—Anuario, 1897.

Tampico, Observatorio Meteorológico.—Boletin de Meteorología, Higiene y Estadistica Médica de Tampico, Jan. to May 1896.

Tiflis, Physikalisches Observatorium.—Beobachtungen, 1894.—Beobachtungen der Temperatur des Erdbodens, 1890.

Toronto, Meteorological Office.—Monthly Weather Review, July 1895 to May 1896.—Toronto General Meteorological Register, 1895.

Trieste, I. R. Osservatorio Astronomico-Meteorologico.—Osservazioni meteorologiche, July 1895 to May 1896.—Rapporto Annuale, 1893.

Turin, Societá Meteorologica Italiana.—Bollettino mensuale pubblicato per cura dell' osservatorio centrale del Real Collegio Carlo Alberto, Dec. 1895 to Dec. 1896.

Upsala, Observatoire Météorologique.—Bulletin mensuel, 1895.

Utrecht, K. Nederlandsch Meteorologische Instituut.—Meteorologisch Jaarboek, 1895.—Onweders in Nederland, 1895.

Vienna, K. K. Centralanstalt für Meteorologie und Erdmagnetismus.—Beobachtungen, June 1895 to May 1896.—Jahrbuch, 1893.—Vierter Jahres-Bericht des Sonnblick-Vereines für das Jahr 1895.

Vienna, K. K. Hydrographisches Central-Bureau.—Ergebnisse der Beobachtungen über die Gewitterregen vom 1 August 1896 in Nieder-Osterreich.—Jahrbuch, 1894.

Vienna, Oesterreichische Gesellschaft für Meteorologie.—Meteorologische Zeitschrift, Dec. 1895 to Nov. 1896.

Washington, Geological Survey.—Annual Report, 1893-4; 1894-5, parts ii.-iv.

Washington, Hydrographic Office.—Pilot Charts of the North Atlantic Ocean, 1896.—Pilot Charts of the North Pacific Ocean, 1896.

Washington, Naval Observatory.—Magnetic Observations, 1894.—Meteorological Observations and Results, 1890.

Washington, Weather Bureau.—Climate and Health, vol. i. No. 4 to vol. ii. No. 3.—Monthly Weather Review, July 1895 to Sept. 1896.—Report of the Chief, 1894.

Watford, Hertfordshire Natural History Society.—Transactions, vol. viii. part vi. to vol. ix. part iii.

Wellington College, Natural Science Society.—Annual Report, 1896.

Wellington, N. Z., Registrar-General's Office.—New Zealand Official Year-Book, 1895.—Statistics of the Colony of New Zealand, 1894.

Yale, University Observatory.—Report for the year 1895-6.

Zi-Ka-Wei, Observatoire Magnetique et Météorologique.—Bulletin mensuel, 1894.

Zürich, Schweizerische Meteorologische Central-Anstalt.—Annalen, 1894.

Presented by Individuals.

Abercromby, Hon. R.—Three Essays on Australian Weather.—Types of Australian Weather, by Henry A. Hunt.

Alexander, F. W.—Report on the Sanitary Condition of the Parishes of Poplar and Bromley within the Poplar District with Vital Statistics, 1895.—Report to the Sanitary Committee of the Board of Works for the Poplar District.—On the cause of Diphtheria: its suggested relation to the main drainage of London.

Allom, A. J.—Meteorology in Tasmania.

Andrée, S. A.—Iakttagelser under en Ballongfärd den 17 Mars 1895.

Bauer, L. A.—Terrestrial Magnetism, vol. i. No. 1.

Baxendell, J.—Meteorological Observations at Southport, Dec. 22, 1895, to Dec. 19, 1896.—The Weather of 1895.—Main features of the months at Southport.

Bayard, F. C.—A dictionary of the Wonders of Nature.—Observations on Mount Vesuvius, Mount Etna, and other volcanoes.—Philosophical Essays by Hugh Hamilton, F.R.S.—Rural Rides, by W. Cobbett.—System of Physical Geography, by D. M. Warren.—The World of Waters.

Bebber, Dr. W. J. von, and Köppen, Dr. W.—Die Isobarentypen des Nordatlantischen Ozeans und Westeuropas, ihre Beziehungen zur Lage und Bewegung der barometrischen Maxima und Minima.

Bell, C. W.—Charts from a Richard Barograph at Yewhurst, East Grinstead, Nov. 23, 1895, to Nov. 28, 1896.

Birch, E. W.—Annual Report on the State of Perak, 1895.

Black, Dr. W. G.—Meteorology, Seaside, English Channel, Winter.—Summer Meteorology, Seaside, with diagrams.

Boyer, H. B.—Atmospheric circulation in tropical cyclones, as shown by movements of clouds.

Brown, A., and Boobbyer, Dr. P.—The Meteorology of Nottingham, 1895.

Buchan, Dr. A.—Specific Gravities and Oceanic Circulation.

Chandler, A.—Meteorological Report for Torquay, 1895.

Clark, J. E.—The Natural History Journal, 1896.

Collenette, A.—Note on the temperature of September 1895.—Sunshine in Guernsey.—The rainfall for 1895.

Cooke, R.—Rainfall in 1895 at Detling, Maidstone (MS.).

Coventry, F.—Results of Meteorological Observations taken at Ketton Hall, Stamford, Jan. 1896 (MS.).

Coxen, Mrs.—Meteorological Observations made at Bulimba, Queensland, July 1895 to June 1896.

Cresswell, A.—Records of Meteorological Observations taken at the Observatory of the Birmingham and Midland Institute, 1895.

Dickson, H. N.—The Movements of the Surface Waters of the North Sea.

Doyle, P.—Indian Engineering, vol. xviii. No. 24 to vol. xx. No. 23.

Druce, F.—Meteorological Observations at Upper Gatton, 1895.

Eaton, H. S.—Returns of Rainfall, etc., in Dorset, 1894.

Editor.—American Meteorological Journal, Jan. to April 1896.

Editor.—Ciel et Terre, 1896.

Editor.—Electrical Review, 1896.

Editor.—Iron and Coal Trades Review, 1896.

Editor.—Nature, 1896.

Editor.—Observatory, 1896.

Editor.—Strand Magazine, Dec. 1896.

Editor.—Travel, 1896.

Farrah, J.—Climate of Harrogate, 1895; comparison with other Health Resorts.—Harrogate Weather in Jan. 1895 and Jan. 1896.

Féral, G.—Observations Météorologiques sur les Pluies Générales et les Tempêtes.

Fox, W. L.—Falmouth Observatory, Meteorological and Magnetical Tables and Reports, 1895.

Frejlach, Dr. J.—Distribution géographique et temporaire des degrés de précipitations dans le bassin hydrographique du Labe en Bohême.

Glyde, E. E.—Meteorological Observations at Tavistock, Devon, Nov. 1895 to Oct. 1896.

Griffith, Mrs.—Meteorological Journal, kept by the late Rev. C. H. Griffith at Strathfield Turgiss, Hants, Jan. 1861 to March 1895 (MS.).

Hall, M.—Clouds and cloud drifts, and Thunderstorms in Jamaica.

Harris, H.—Das Klima von Frankfurt-am-Main.

Harrison, Dr. C.—Annual Report of the Medical Officer of Health and Public Analyst, city of Lincoln, 1894.

Hill, G. H.—Returns of the Rainfall in the Glasgow, Manchester, Ashton, Dewsbury, Stockport, Halifax, Blackburn, Holme Reservoirs, Oldham and Batley Waterworks Districts, 1895.

Holzel, E.—Die Abfluss und Niederschlagsverhältnisse von Böhmen von Dr. Vasa Ruvarac nebst Untersuchungen über Verdunstung und Abfluss von grösseren Landflächen, von Prof. Dr. Albrecht Penck.

Hopkinson, J.—Meteorology of Middlesex and Hertfordshire, Dec. 1895 to Aug. 1896.

Hunter, J.—Meteorological Observations at Belper, 1896.

Kammermann, A.—Résumé météorologique de l'année 1895 pour Genêve et le Grand Saint Bernard.

Kiddle, H. C.—Notes on the Rainfall of the Southern Riverina, 1872-94.

Klossovsky, A.—Les pluies torrentielles au sud-ouest de la Russie, 1886-92.

Maclear, Admiral J. P.—Desvio da Agulha Magnetica a bordo por J. C. de Brito Capello.—The Wet and Dry Seasons of England, 1846-60.

Markham, C. A.—Meteorological Report for Northamptonshire, Oct. 1895 to March 1896.

Marriott, S.—To Winnipeg, Manitoba, and back.

Marshall, S. A.—Rainfall in the Lake District, Dec. 1895 to Oct. 1896.

Marvin, C. F.—Kite experiments at the Weather Bureau.

Mawley, E.—Meteorological Observations taken at Rosebank, Berkhamsted, Dec. 18, 1895, to Dec. 9, 1896.—The Rosarian's Year-Book, 1896.

Mellish, H.—The Weather of 1895 at Hodsock Priory, Worksop.

Mill, Dr. H. R.—Geography as a Science in England.

Mossman, R. C.—On Sunshine with different winds at Edinburgh.—On the diurnal range of temperature variability at the summit and base of Ben Nevis, Lady Franklin Bay, and Hongkong.—On the number of Auroras observed over the N.E. of Scotland from 1773-1894 during each day of the year.—On the Seasonal Death Rate from certain Diseases in Edinburgh during the period 1878-94, with remarks on the relation between weather and mortality.—Results of Meteorological Observations taken in Edinburgh during 1895.—The Clyde Sea Area, part iii., Distribution of Temperature, by Dr. H. R. Mill.—The frost of 1895 in Scotland.—The Meteorology of Edinburgh, part i.

Paget, J.—Weekly Charts from a self-recording Richard barograph at Stuffynwood Hall, Mansfield, 1892-5 (MS.).

Palazzo, L.—La stazione Meteorica e Geotermica annessa ai Laboratori Scientifica della Direzione di Sanitá in Roma.

Parnaby, J. M.—Meteorological Report for Albert Park, Middlesborough, Dec. 1895 to Nov. 1896.

Preston, A. W.—Meteorological Notes, 1895, from observations taken at Brundall, Norfolk.

Prigg, H. V.—Meteorological Report of the Borough of Plymouth, 1895.

Prince, C. L.—The summary of a Meteorological Journal kept at Crowborough Hill, Sussex, 1895.

Propert, Dr. W. P.—Meteorological Summaries at St. David's, Pembrokeshire, 1881-90.

Ramsay, A.—The Scientific Roll : Climate, Baric Condition, No. 8.

Randall, H. J., Junr.—Charts from a Richard Barograph at Bridgend, Glamorganshire, Aug. to Nov. 1896 (MS.).

Ravenstein, E. G.—Climatology of Africa (Fourth and Fifth Reports of the British Association Committee).

Rotch, A. L.—The New Meteorological Observatory on the Brocken.

Russell, H. C.—A map showing the average monthly rainfall in New South Wales.—Current Papers.—Icebergs in the Southern Ocean.—On periodicity of good and bad seasons.—The meteor of June 27, 1894.

Salle, O.—Das Wetter, 1896.

Schlich, Dr. W.—Schlich's Manual of Forestry, vol. v.: Forest Utilisation, by W. R. Fisher.

Sheward, R.—Annual Report of the Meteorological Observations at Eastbourne, 1895.

Slade, F.—Meteorological Observations taken at Beckford, Tewkesbury, 1895.

Smith, W. H.—City of Carlisle. Report of the City Surveyor to the Sewage Disposal Committee, July 1896.

Symons, G. J.—Meteorological Journals kept by the late Dr. J. W. Tripe at Hackney, May 1857 to July 1866, and Jan. 1879 to Oct. 1883 (MS.).—On the meteorology of Scotland during the half-year ending Sept. 30, 1857, by J. Glaisher.—Scientific Weather Forecasting.—Symons's British Rainfall, 1895.—Symons's Monthly Meteorological Magazine, 1896.

Taylor, Capt. E. R.—Return of Meteorological Observations made at Ardgillan, Balbriggan, Ireland, 1895.

Taylor and Francis (Messrs.).—Taylor's Calendar of the Meetings of the Scientific Bodies of London, 1896-7.

Teisserenc de Bort, L.—Rapport sur les Mesures des Hauteurs et des mouvements des nuages par la photographie à Trappes.

Trombetta, J.—Das Klima von Görz.

Tyrer, R.—Meteorology of Cheltenham, 1895.—Rainfall in the County of Gloucester, Dec. 1895 to Nov. 1896.

Vincent, J.—Examen Critique de la Carte Pluviométrique de la Belgique de M. A. Lancaster.

Wagstaffe, W. W.—Ten years of Temperature and Rainfall at Sevenoaks.—The Invalid's day and its rainfall.

Ward, R. de C.—Meteorological Observations in Schools.—Meteorology as a University Course.

Warry, Dr. J. K.—Report on the Sanitary Condition of the Hackney district, 1893-4.

Waters, R.—Sunshine in the English Lake District, 1895.

Westman, J.—Quelques tableaux de réduction pour les mesures les photogrammétriques des nuages.

Wiese, W.—Die Kreisläufe der Luft nach ihrer Entstehung und in einigen ihrer Wirkungen.

Wiesner, J.—Beiträge zur Kenntniss des tropischen Regens.

Wilmhurst, A. J.—Temperature and Rainfall at Manor Park, Essex, Dec. 1895 (MS.).

Wise, D. H.—Administration Report of the State of Pahang, 1895.

Woeikof, A.—Das Klima Centralasiens nach den Beobachtungen von Prschewalsky.—Das neue meteorologische Observatorium der Universität Odessa.—Zum Klima des Amurlandes.—Zur Frage der Erstreckung des Eisbodens und geothermische Beobachtungen in Sibirien.—Zur Verbreitung des Eisbodens in Transbaikalien.

Photographs.

Russell, H. C.—Clouds taken at Sydney Observatory, N.S.W., 1894 (60 photos).

Symons, G. J.—Visit of the Members of the International Meteorological Conference to the Observatoire de Météorologique Dynamique, Trappes, Seine et Oise, Sept. 21, 1896.

Lantern Slides.

Mawley, E.—Frost in Highlands of Scotland, Feb. 1895.—Rosebush in full bloom, Berkhamsted, 1895.

Plaque.

White, W.—Plaque of H. Perigal, Treasurer of the Royal Meteorological Society.

APPENDIX VI.

REPORTS OF OBSERVATORIES, Etc.

The Meteorological Office.—Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Nav. Lieut. C. W. Baillie, F.R.A.S., Marine Superintendent.

MARINE METEOROLOGY.—*Current Charts for all Oceans.*—As explained in last report these charts are being generalised, at the Admiralty, by an officer detailed to assist the Hydrographer in the work. The volume of charts for the Indian Ocean has appeared; these are monthly in order to show the variations in currents due to the changes of Monsoons. It is not yet decided if each month will be reproduced in the volumes for the Atlantic and Pacific Oceans. It should be remarked that all currents under 6 miles a day are counted as "no current," and that no records from any of the very fast steamers, now employed in carrying mails, have been utilised.

The charts for the *South Indian Ocean* (Cape of Good Hope to New Zealand) are still in the engraver's hands.

South Atlantic Ocean.—The materials contained in the Office logs for this region, and that which extends in the Pacific to 100° W., thus including both coasts of South America, have now been extracted, and recourse will consequently be had to the logs of H.M. ships to obtain all available information for regions not traversed by ordinary trade routes.

Weather Telegraphy.—No change has been made in the system of reporting during the year. The *Daily Weather Report* for 1896 is now complete. Its second volume (July to December) contains tables showing for the several telegraphic reporting stations in these islands, for 25 years in most cases, the means of pressure and of dry bulb and wet bulb temperature at 8 a.m., Greenwich time; also the monthly means of the maximum and minimum temperatures, and of the maximum and minimum combined, together with the extremes of the maximum and minimum temperatures in each month for the whole period. The mean rainfall, from which latter element the interval, in most cases, is 30 years, is given in a separate table, and sunshine for 15 years at ten stations.

The *Weekly Weather Report* for 1895 and 1896 are now both complete; the former gives a table of maximum and minimum and mean temperatures for 74 stations over a long period—25 years in most cases. Rain, for 30 years, is similarly treated, and bright sunshine is given for 44 stations, but for this element the number of years is less, never exceeding 15.

British Rain, 1881-90.—These tables are now in print. The maps are being prepared for engraving, and the volume may be confidently expected in the summer.

Land Meteorology of the British Isles.—The volume of *Hourly Mean Readings for Five-day Periods for the Five Observatories* for 1893 has appeared, and that for 1894 is in hand.

The volumes of *Results of Observations from Stations of the Second Order* for 1892 and 1893 have been published, and that for 1894 is in an advanced stage.—*February* 10, 1897.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer-Royal.

In last year's report attention was drawn to the fact that the building operations then in progress interfered materially with the meteorological work of the Royal Observatory. Early in the summer this source of interference was to a great extent removed, the north wing of the new Physical Observatory on the south ground having been completed. The space now available, however, for the purposes of the Meteorological Department is so much curtailed in area, that a supplementary subsidiary station where free circulation of air can be secured is very desirable. It is hoped to establish this in an open position in Greenwich Park in connection with the site for the proposed Magnetic Pavilion.

In consequence of the extension of the Physical Observatory buildings, the sunshine instrument has been removed from the roof of the Magnetic Observatory to a commanding position above the roof of the Octagon Room. It has recently been pointed out by Mr. Marriott and also by Mr. Ellis that the results given by this instrument have apparently fallen off in amount—this conclusion being based on a comparison of results obtained at Kew and Greenwich during a series of years. As resulting from this comparison the glass globe of this instrument, which appears to be somewhat dull and opaque, has been changed for another globe of clearer glass presented to the Observatory by the late Mr. Campbell in 1881. The defective globe has been mounted on the bowl of the original Campbell instrument side by side with the Campbell-Stokes, and a series of registers is being taken with both instruments for comparison of the two glass globes.

One of the springs of Osler's pressure apparatus has been renewed, and the instrument is working satisfactorily. The old Whewell anemometer is on loan to the Science and Art Department for exhibition at the South Kensington Museum, and some typical photographic registers have been exhibited at the Glasgow Photographic Exhibition.

Briefly summarised, the following are the leading features of the weather in the year 1896 :—

The temperature ranged between 24°·3 on February 25 and 91°·1 on July 14. The mean annual temperature was 50°·1, being 0°·7 above the average. The high barometer readings recorded during the anticyclonic systems in January were very remarkable. On January 9 a reading of 30·73 ins. was recorded, and on January 30 a second maximum of 30·74 ins., and these were the highest readings noted since the maximum of January 18, 1882, which was 30·79 ins. The total rainfall for the year was 22·42 ins., being 2·12 ins. less than the average amount. There was a remarkable deficiency of rainfall in each of the months of January, February, April, May, and July, the total fall for those months amounting to 2·886 ins., as compared with an average of 9·607 ins. The month of September on the contrary was the wettest on record, the rainfall amounting to 5·54 ins., which is 3·29 ins. in excess of the average amount. The largest rainfall previously recorded in September in the fifty-five years, 1841-95, was 4·12 ins. in 1871.—*April* 6, 1897.

ROYAL OBSERVATORY, EDINBURGH.—Ralph Copeland, Ph.D., F.R.S.E., Astronomer-Royal for Scotland.

The regular meteorological record was begun on January 1, 1896, at the new Royal Observatory, Blackford Hill.

The thermometers are mounted in a louvred screen erected in the open space to the south-west of the main building, and comprise dry and wet bulb as well as maximum and minimum ; daily readings of these are taken at 9 a.m. and 9 p.m.

An 8-inch rain gauge, 442 feet above sea-level, is placed on the grass near the thermometer screen, while a 5-inch gauge is on the roof of the main building, 18 feet above the grass gauge, and thus 460 feet above sea-level. These are read each day at 9 a.m. and the readings entered for the previous day, in accordance with the plan adopted by Mr. Symons.

The standard barometer is mounted in the barograph room, with its cistern 441 feet above sea-level ; daily readings are made at 9 a.m. and 9 p.m. The King recording barograph, by Casella, has been in continuous action since the beginning of 1896.

The five rock thermometers at Calton Hill continue to be read once a week by one of the staff of the Royal Observatory.

It was not found possible to start the recording anemometer at the beginning of the year, as it was decided to mount it on a tall iron lattice pillar, above the porch of one of the detached observing houses on the high ground to the west of the Observatory; this porch was not completed until April, when the anemometer was erected. The pillar is distant from the west dome 166 feet, and from the east dome 310 feet, the summit of the former being 6 feet below and that of the latter 10 feet above the level of the revolving cups of the anemometer; these are the most favourable conditions that could be secured without making the pillar unreasonably high, and it is hoped that the wind record will not be seriously affected by the neighbourhood of the buildings. The cups are 38 feet above the ground. The connecting rods for the recording apparatus were attached in July; the record has been carried on without interruption since the 17th of that month.

Remarkably high velocities were recorded during the gales of October 8 and December 26, 1896. At 5 a.m. on October 8 the wind blew from the South with a velocity of 40 miles per hour, increasing to 45 miles before 8 a.m. and to 60 miles at 9 a.m., from which hour till noon the average was as high as 68 miles per hour; it then fell off to 50 miles at 2 p.m. and to 40 miles at 8 p.m. On December 26 the highest velocity recorded was 67 miles per hour between 2.30 and 4 p.m.

Abstracts of the principal meteorological observations are sent each month to the Scottish Meteorological Society, and appear in the returns of the Registrar-General for Scotland.—*February* 6, 1897.

KEW OBSERVATORY, RICHMOND, SURREY.—Charles Chree, Sc.D., Superintendent.

The several self-recording instruments for the continuous registration of atmospheric pressure, temperature of air and wet bulb, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year, and the standard eye observations for the control of the automatic records duly registered.

The tabulations of the meteorological traces have been regularly made, and these, as well as copies of the eye observations, with notes of weather, cloud, and sunshine, have been transmitted, as usual, to the Meteorological Office.

Electrograph.—As a result of experimental investigations made in the present and preceding year, several important changes have been made in the water-dropping apparatus. A new water reservoir and overflow tube have been obtained, and the jet has been brought much nearer the electrometer. The auxiliary battery having considerably deteriorated, it was sent to the makers on November 20, and the instrument in consequence remained out of action until the end of the year.

Determinations of the scale value were made on March 30, June 27, July 27, and October 24, by direct comparison with the portable electrometer, White No. 53.

Atmospheric Electricity.—The eye observations referred to in last year's report have been discussed.[1] Some further experiments have been carried out on similar lines, and in particular comparisons have been made of the potential at the spot where the jet of the water-dropper breaks up with that at a station outside the immediate influence of the Observatory buildings.

Aneroid Barometers.—A large number of experiments have been made in continuation of those mentioned last year, and the readings have been reduced. Further experiments are contemplated. In the meantime the results are being worked up.

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[1] *Proceedings of the Royal Society*, vol. lx. p. 96.

Nocturnal Radiation.—The observations with minimum thermometers referred to last year have been continued.

Fog and Mist.—The observations of a series of distant objects, referred to in previous reports, have been continued. A note is taken of the most distant of the selected objects which is visible at each observation hour.

Dines Pressure-Tube Anemometer.—A self-recording tube anemometer belonging to the Meteorological Office was erected on the roof early in December. Its vane is approximately at the same level as the cups of the standard Robinson anemometer.

Electrical Resistance Thermometers.—Early in the year a platinum resistance thermometer was buried underground along with two iron resistance thermometers of a type invented by Prof. H. Callendar, F.R.S., and Mr. E. H. Griffiths, F.R.S. During the year readings of earth temperatures have been taken usually twice a day, and a report on the behaviour of the instruments has been submitted to the Meteorological Council, on whose behalf the experiments were undertaken.

During the year 1896 the air temperature ranged from 22°·8 on February 26 to 84°·3 on July 14. The mean was 50°·0. The maximum temperature in the sun's rays (black bulb *in vacuo*) was 146° on July 7, and the minimum on the ground was 9° on February 26. 1436 hours of sunshine were recorded, giving a mean percentage of 29, which is the average value for the past 20 years. The sunniest month was May, with a mean percentage of 48. August and September were each 10 per cent below the average, and the value for the latter month—25 per cent—is the minimum recorded. The total rainfall was 20·975 ins.; the spring was very dry, and the autumn very wet, May with 0·175 in. and September with 5·065 ins. being the two extreme values. The remarkably small fall of 0·175 in. is by far the lowest total for May yet recorded here; on the other hand, the value for September is the maximum for that month.—*March* 31, 1897.

RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, F.R.S., Radcliffe Observer.

The staff has remained unchanged during the year. The photographic and self-recording instruments have worked without failure.

The eye-readings have been taken as usual, and reports sent daily by telegram to the Meteorological Office, monthly to the Registrar-General and the local newspapers; and, upon application, to sanitary and other authorities. The weekly amounts of rainfall have, by request, been forwarded to the authorities at Windsor, who are interested in the prevention of floods in the valley of the Thames.

A set of photographic curves showing the diurnal changes of temperature on fine days for the different months of the year, and others of general interest, were sent to the Exhibition of Photography held at Glasgow.

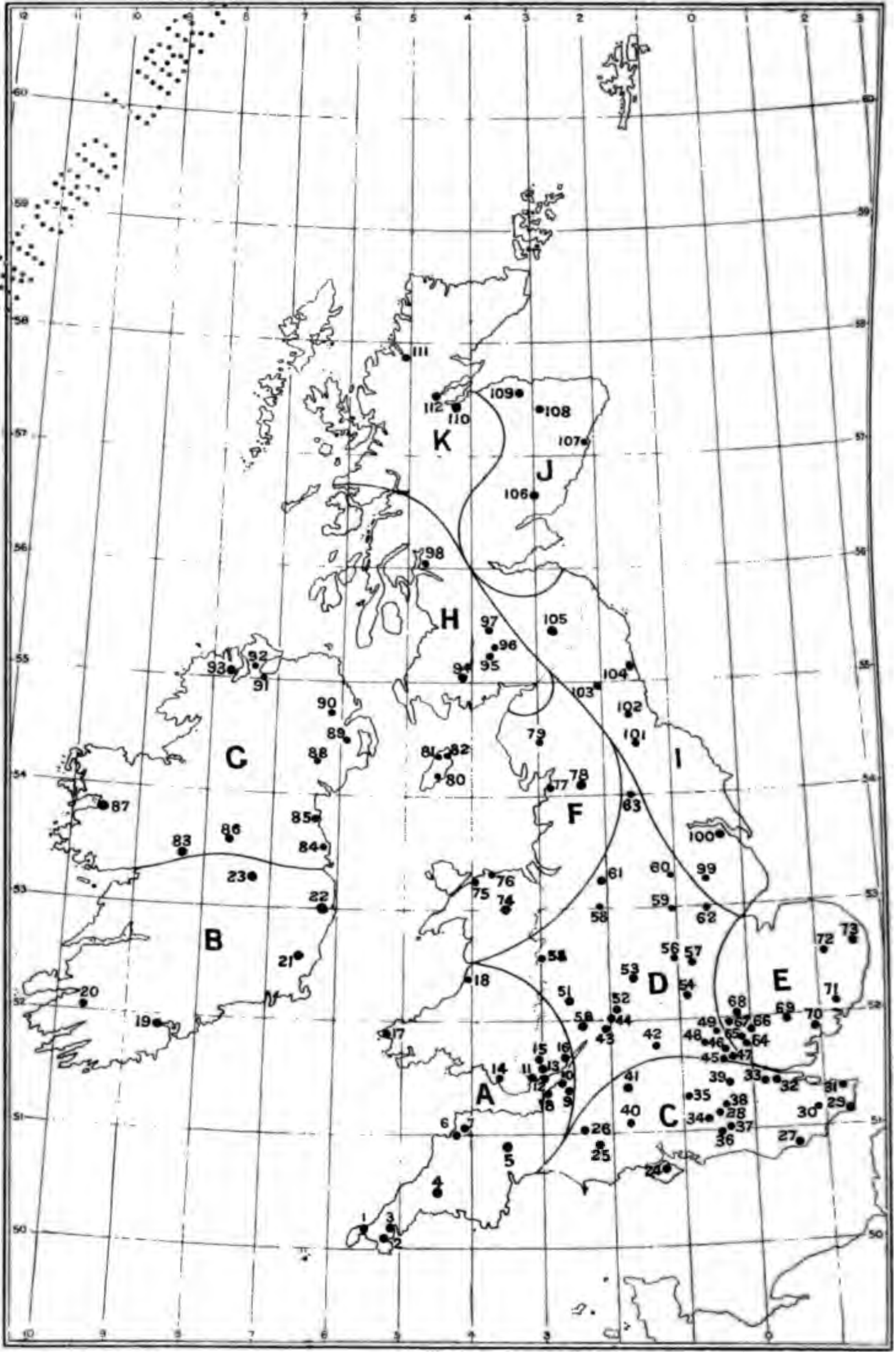
The printed volume of *Radcliffe Observations* containing the Meteorological results for the years 1888-89 was distributed in the early part of the year.

A Griffiths-Callendar temperature bridge, and four platinum thermometers have recently been procured from the Cambridge Scientific Instrument Company, and the thermometers have been sunk to the respective distances of 6 in., 1 ft. 6 in., 3 ft. 6 in., and 5 ft. 10 in. below grass in undisturbed ground.

The following are the chief characteristics of the weather noted at Oxford in the year 1896:—

The mean reading of the barometer for the year was 29·793 ins., being 0·071 in. above the mean for the preceding 41 years. The highest reading was 30·696 ins. on January 9, and the lowest 28·406 ins. on December 6, the difference being 2·290 ins.

MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1896.



For the Names of the Stations see List of Observers, Page 127.

The mean temperature of the air was 49°·6, being 0°·8 above the mean for the preceding 68 years. The highest temperature was 83°·2 on July 13, and the lowest 21°·4 on February 26, the difference being 61°·8.

The record of bright sunshine amounted to 1430 hours, being 6 hours in excess of the mean for the preceding 16 years. The recorded sunshine for the months of May, June, and July were respectively 33, 28, and 27 hours above the average.

The total rainfall was 24·975 ins. on the ground, being 1·289 in. below the mean for the preceding 81 years. The first seven months of the year were generally dry; the rainfall for this period being below the average to the extent of 5·392 ins.

The month of September, however, was remarkable for its heavy rainfall, 6·009 ins.; it is the largest record of rainfall in the month of September at this Observatory during the preceding 81 years, and is 3·326 ins. above the average. During the sixteen days, August 30 to September 14, the rainfall amounted to 4·873 ins.—*January* 26, 1897.

REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1896.

By EDWARD MAWLEY, F.R.H.S., President.

(Plate I.)

[Read February 17, 1897.]

THERE have been no great changes in the list of observers since the last report was issued, and those made have been mostly in the required direction, the general tendency being towards a more uniform distribution of the observing stations over the British Isles. The total number of observers in 1896 was 115, against 118 in the previous year.

The following are the changes referred to:—No returns were sent in from Woodenbridge in District **B**; Carisbrooke, Whitchurch Canonicorum, Pennington, Strathfield Turgiss, Farnborough, Cranleigh, Willinghurst, Addlestone, and Reading in District **C**; Breinton in District **D**; and Thirsk in District I. On the other hand, new stations have been started at Cardiff and Bridgend in District **A**; Wye, Westgate-on-sea, and Chiddingfold in District **C**; Conway in District **F**; Ardgillan and Piperstown in District **G**; and Corbridge-on-Tyne in District I.

I have reluctantly had to refuse during the past year several kind offers to take Phenological observations for the Society, owing to the localities in which the applicants reside being already sufficiently well represented. New observers for the north-west and north-east of England, also for almost any part of Ireland or Scotland, would, however, be gladly welcomed.

Now that observations for six years are available, taken on the same uniform plan, and in most cases by the same observers, I have thought it well to substitute for the approximate averages previously used for the purposes of comparison, those derived from the actual observations made in the different districts during those years. This I cannot but regard as a great improvement, especially as three of the six years were forward ones, while the other three had proved almost equally backward; therefore the new means are not likely to differ greatly in the best represented districts from the true values whenever these can be ascertained. The two sets of averages vary but very slightly indeed from each other when the whole thirteen plants are taken, but differ considerably in the case of certain individual plants. The "approximate averages" previously used, which were principally based upon those given in the Rev. T. A. Preston's *Results of Twenty Years' Observations* at Marlborough, are much earlier for the first four plants than those derived from the six years' observations at the Society's stations; are either the same, or almost the same, for the next five plants, but come out nearly as late, as the first four are early, for the remaining four plants.

In those districts where there have not been sufficient observers until recently to allow of a six years' average being computed, averages have been obtained for the different plants by comparing the available dates for such districts with similar dates for the five best represented districts, as being the nearest approximations at present available. These means are inserted in the Tables under the title of "approximate averages."

The variations from the average in Table I. will be found to differ but slightly from those given in similar Tables which have appeared in previous Reports, although the averages themselves have been so differently computed.

TABLE I.—MEAN RESULTS, WITH THEIR VARIATIONS FROM THE SIX YEARS' AVERAGE, FOR THE THIRTEEN PLANTS IN ALL THOSE DISTRICTS WHERE THERE HAVE BEEN, THROUGHOUT THAT PERIOD (1891-6), SUFFICIENT OBSERVATIONS TO WARRANT COMPARISONS BEING MADE.

YEARS.	Eng. S.W.		Eng. S.		Eng. Mid.		Eng. E.		Eng. N.W.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+12	144	+11	150	+12	147	+12	150	+10
1892	139	+ 7	138	+ 5	144	+ 6	143	+ 8	147	+ 7
1893	118	−14	122	−11	125	−13	123	−12	128	−12
1894	126	− 6	130	− 3	135	− 3	127	− 8	137	− 3
1895	139	+ 7	138	+ 5	141	+ 3	138	+ 3	144	+ 4
1896	125	− 7	128	− 5	132	− 6	130	− 5	134	− 6
Mean	132	...	133	...	138	...	135	...	140	...

Explanation of the Dates in the Tables.

1– 31 are in January.
32– 60 ,, February.
61– 91 ,, March.
92–121 ,, April.
122–152 ,, May.
153–182 ,, June.
183–213 are in July.
214–244 ,, August.
245–274 ,, September.
275–305 ,, October.
306–335 ,, November.
336–366 ,, December.

The Winter of 1895-6.

This was a warm winter, but not nearly as mild as was generally supposed. In fact, only in the south of Ireland, and the west and north of Scotland did the mean temperature of the quarter exceed the average by 2°. The fall of rain during this season proved very slight, particularly in the south-western, southern, and midland counties of England, and in the west of Scotland. There was also everywhere a marked deficiency of sunshine.

Seldom has there occurred in the British Isles a winter so favourable in all respects for the farmer. The early sown wheat, owing to the dryness of the soil and the paucity of sunshine, never became too forward, while the unseasonable warmth of the ground and the absence of keen frosts enabled that sown late in the autumn to become firmly rooted and make some little growth during the season. Moreover, the almost unbroken mildness of the weather favoured the maintenance of an abundant supply of green keep of all kinds for sheep and cattle. The sowing of spring corn was commenced singularly early and carried out under unusually advantageous conditions, the soil in February being remarkably dry and friable for a winter month. In the gardens there was always a plentiful supply of vegetables. The earliest flowers of the year, such as winter aconites, snowdrops, etc., came into blossom much in advance of their usual time.

The fertile flowers appeared on the hazel in all the districts earlier than in any of the previous five years except 1894, and in some earlier than in any of those years.

The song-thrush was heard much earlier than in any of the preceding five years. The mean date for the honey-bee first visiting flowers also comes out earlier than in any of those years.

The Spring.

The spring quarter proved very warm, the departure from the average in mean temperature ranging between + 1°·4 in the East of England to + 3°·0 in England South-west and Scotland East. March was everywhere a wet month, but in all the districts except Scotland North there was a deficient rainfall during the remainder of the season. In March and April the distribution of bright sunshine was very irregular, but in most districts the record was below the mean. May, on the other hand, was a remarkably sunny month in nearly all parts of the kingdom.

At the beginning of the season, and also throughout the greater part of it, the outlook to the agriculturist continued most promising. The March rains, although interfering with the cultivation of the land for spring crops, were much wanted for the pastures and meadows. Indeed, in many parts of these islands, the grass during that month was as thick and forward as it often is in the early part of May. In April the planting of spring corn and other seeds was proceeded with, but the ground, owing to the rains of the previous month which had beaten down the surface, was not in as favourable a condition as in February.

All, however, may be said to have gone well until about the middle of May, when the dry weather of the preceding six weeks was beginning to be seriously felt in many parts of England and Ireland. The spring corn, where not got in early, began to flag, the soil was too dry to sow turnips and swedes, while the growth of the grass in the pastures was brought almost to a standstill. The seeds sown during May in the gardens, owing to the dry state of the soil, germinated slowly, and in many cases did not come up at all.

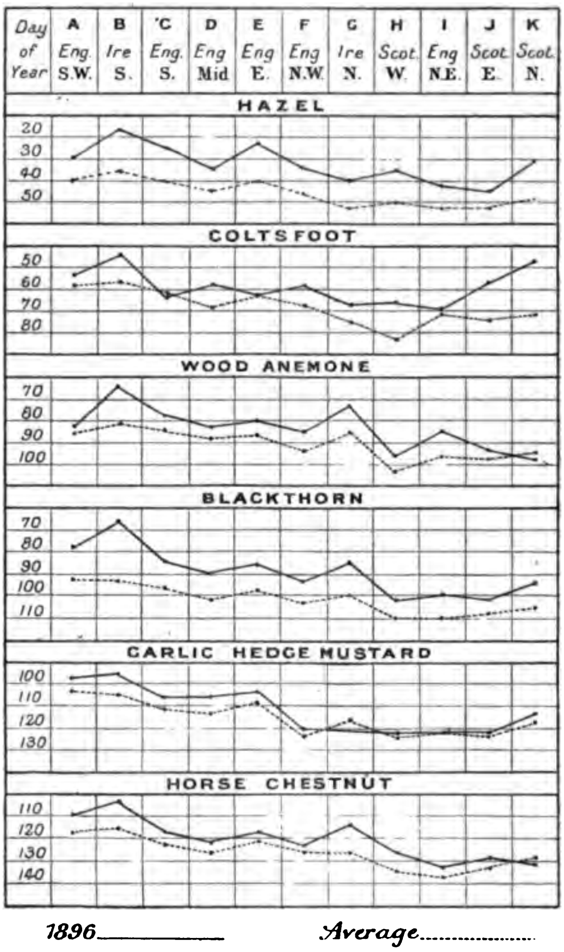


FIG. 1.—Mean dates (day of year) of flowering of plants in 1896 as compared with the six years' average 1891-6.

A noteworthy feature of the season was the abundant blossom on nearly all kinds of flowering trees and shrubs, and especially upon the hawthorn. Fruit trees of all kinds were also almost everywhere laden with bloom.

The two principal insect pests of the spring and early summer were leafage-moth caterpillars of different kinds, and greenfly. The former proved very destructive over a large area to the foliage of the oak, the apple, and the hazel. In many instances the oaks were entirely divested of their leaves, and consequently appeared as bare as in mid-winter.

The dates of all the plants which flowered during this season were remarkably early. Taking the British Isles as a whole, the only one of the previous five years in which the coltsfoot was as early in blossom was 1894. The mean date for the wood-anemone was the earliest of the six years. The blackthorn, garlic-hedge-mustard, horse-chestnut, and hawthorn appeared in flower only earlier in 1893 and 1894, while the white ox-eye and dog-rose were in advance of every year except 1893.

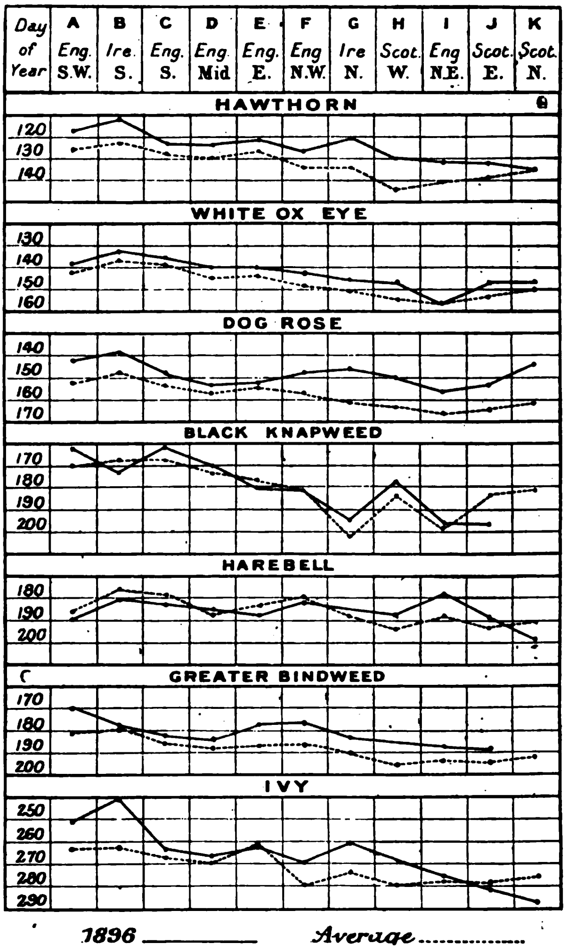


Fig. 2.—Mean dates (day of year) of flowering of plants in 1896 as compared with the six years' average 1891-6.

The swallow, the cuckoo, and the nightingale made their appearance later than in any year since 1892, and the flycatcher later than in any year since 1891.

The wasp was first seen at about its average date for the six years, while the orange tip and meadow brown butterflies were also early, but the small white butterfly appeared somewhat late.

The Summer.

June was very warm, especially in all the English districts where the variation in mean temperature from the average ranged from $+3^\circ{\cdot}0$ to $+3^\circ{\cdot}8$. July also proved warm in England, but of about average temperature elsewhere, while August was more or less cold in all parts of the kingdom. Taking the summer as a whole the rainfall was in defect of the mean throughout England, but above the average in Ireland and the greater part of Scotland. In most districts June and July were remarkably sunny months, while August, on the other hand, was almost as unseasonably cloudy.

The rain which fell at the beginning of June proved very beneficial to the cereals, and particularly to the late sown spring corn, while the roots were also benefited. But these showers came too late to save the hay, which was the smallest crop since that of 1893. It was, however, harvested in excellent condition. The salutary effect of the wet weather on the various crops in the early part of June soon passed away, owing to the subsoil having previously become so remarkably dry, and to the drying character of the winds which succeeded; so that the roots and grass may be said to have remained virtually at a standstill throughout the rest of the season, the pastures presenting during that period a parched and burnt-up appearance. That deep-rooting cereal, the wheat, beyond being shorter than usual in the straw, seemed scarcely to receive any check at all from the dry weather. But it was not so with barley and oats, the latter of which suffered considerably. The foregoing description applies to the greater part of England and Ireland, but in the northern counties of England, and throughout Scotland, the conditions were most favourable. Indeed, all the crops, including the grass, are said at this time to have presented a most luxuriant appearance in the north.

The corn harvest began remarkably early. In fact, a good deal of corn had been cut in the warmer districts by the middle of July. Sir J. B. Lawes states that at Harpenden the harvest commenced on July 18, or earlier than in any year since 1868, twenty-eight years ago. The harvest of 1896 was not only singularly early, but lasted but a short time, the fields throughout the principal part of England being nearly all cleared by the middle of August. The quality of the grain was, moreover, remarkably good.

During the spring and summer, flowers of all kinds, both in the garden and in the field alike, made their appearance, as a rule, unusually early, and were abundant while they lasted, but soon over. Vegetables made but poor growth, especially peas, while the lawns remained brown throughout nearly the whole of the summer months, in all but the cooler districts of these Islands. In many localities the leaves on the trees began to change colour remarkably early owing to the drought, and in many cases some of the limes had lost all their foliage before the end of the season. The surprising number of galls on the oaks is noted by several observers. Earwigs were exceedingly numerous in some parts of the country; while Miss Ormerod states that the turnip grubs made their appearance at an unusually early date, and in such numbers that great injury was done to the root crop.

As had been the case in the spring, plants came into blossom much in advance of their usual time.

Taking the mean dates for the whole country, the black knapweed flowered earlier than in any of the preceding five years except 1893, the harebell earlier than in any year except 1893 and 1895, and the greater bindweed earlier than in any year except 1893.

The Autumn.

September was about seasonable in temperature, but the rainfall in most districts proved unusually heavy and persistent, and there was very little sunshine. Throughout October and November the weather remained cold, and in the former month for the most part wet, whereas in November there was scarcely any rain.

The heavy rains of September caused the grass and root crops to make rapid growth, and from this time there was never any lack of keep in the pastures. The magnificent grain crops in Scotland and all the colder districts were only ready for cutting about the time the wet weather had set in. Consequently the harvest in the north made slow and unsatisfactory progress, and a great part of the corn was much damaged by sprouting or discoloration. Throughout the country the repeated falls of rain during September and October also greatly interfered with the cultivation of the land. Fortunately November continued so dry and the soil in such admirable working condition, that the sowing of wheat and other winter crops proceeded without interruption during the whole of the month. The warmth and dryness of the summer must have greatly increased the fertility of the land, and notwithstanding the subsequent heavy rainfall, the subsoil remained for the most part warm and dry throughout the season.

The autumn of 1895 was so favourable for maturing the fruiting shoots of all trees and shrubs, the winter which followed so mild, and the flowering period so genial, that it is not surprising to find that in nearly all parts of the country, wild fruits, such as acorns, chestnuts, hawthorn and holly berries, and the hips of the dog-rose, were singularly fine and abundant. The autumnal tints on the trees, owing to the continued wet and boisterous weather, were very poor. Favoured by the heavy rains of September and the comparatively warm nights, mushrooms and other fungi were remarkably numerous in many localities.

The wheat crop was the best known for many years. According to a preliminary statement issued by the Board of Agriculture in March 1897, the estimated yield of wheat per acre in Great Britain in 1896 exceeded that for any other year since official returns were first published in 1885. Barley is represented as over average in England and Scotland, but below the average in Wales, while oats were everywhere a poor crop except in Scotland. In the same official return it is stated "that the effect of the early drought was especially notable in the four south-western counties of Somerset, Dorset, Devon, and Cornwall, wherein a wheat crop of less than 28 bushels, a barley crop of a little more than 24½ bushels, and an oat crop of hardly over 27 bushels per acre appear to have been reaped." On the other hand, in Norfolk, Lincolnshire, and the East Riding of Yorkshire all three crops were considerably heavier than in any other part of England, the mean estimates being as follows: wheat 38·3, barley 37·6, and oats 44·6 bushels. The estimated yield for the whole of England is given as 33·9 bushels for wheat, 33·6 bushels for barley, and 37·6 bushels for oats. From some estimates given in the *Irish Farmer* it appears that the crops of both wheat and barley amounted to a good average in Ireland; while the yield of oats, on the other hand, is reported as very unsatisfactory. Taking the British Isles as a whole the corn harvest began nearly a fortnight in advance of the mean date for the previous seven years, and in all but the northern districts earlier than in any of those years. Beans and peas yielded badly, except in the north of England and in Scotland, where they were about average. Potatoes were almost everywhere a good crop. The early varieties were, however, in many districts much diseased, while the later sorts were injured by supertuberation. Turnips and mangolds were poor throughout England and many parts of Ireland, but proved good crops in Scotland.

Turning now to the garden and orchard crops. The crop of apples was in most districts a small one, while the yield of pears was still more deficient. Plums were also generally poor, except in Scotland and Ireland, where there was a good yield. Raspberries, currants, gooseberries, and strawberries, on the other hand, were generally abundant.

The ivy, like the twelve plants on the list which had preceded it, came into blossom remarkably early, the only earlier mean date for this flower being that for 1893.

Swallows remained in this country later than usual, indeed, according to the returns sent in, later than in any year since 1891.

The Year.

The phenological year ending November 1896 was an extremely warm and dry one. Throughout the flowering season wild plants came into bloom much in advance of their usual time, indeed, as a rule, earlier than in any recent year with the exception of 1893. The wealth of blossom on nearly all kinds of trees and shrubs was a noteworthy feature of the spring and early summer, while the abundance of wild fruits during the autumn was even more exceptional.

From an agricultural and horticultural point of view the one great drawback to a year which must otherwise have proved one of the most bountiful on record, was a drought that may be said to have lasted almost without a break, at all events as far as vegetation was concerned, throughout the greater part of the British Isles from March to September. Taking the country as a whole, the wheat crop was the largest and best for many years, while there was a good yield of barley and potatoes. There were also good crops of all the small fruits. With these exceptions, however, both farm and garden produce must be regarded as having been indifferent—especially the crop of hay, which was very scanty.

TABLE II.—List of Observers.

Station.	County.	Height above Sea-level.	Observer.
A		Ft.	
1. Marazion	Cornwall	40	F. W. Millett.
2. Mawnan	Cornwall	200	Miss R. Barclay.
3. Falmouth	Cornwall	190	Miss Willmore.
4. Liskeard	Cornwall	400	S. W. Jenkin, C.E.
5. Tiverton	Devon	270	Miss M. E. Gill.
6. Westward Ho	Devon	130	Miss Patterson.
7. Barnstaple	Devon	90	T. Wainwright.
8. Sidcot	Somerset	200	W. F. Miller.
9. Long Ashton	Somerset	280	Miss H. Dawe.
10. Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
11. Penarth	Glamorgan	120	G. A. Birkenhead.
12. Cardiff	Glamorgan	40	A. A. Pettigrew.
13. Castleton	Glamorgan	80	F. G. Evans, F.R.Met.Soc.
14. Bridgend	Glamorgan	90	H. J. Randall, Junr., F.R.Met.Soc.
15. Bassaleg	Monmouth	25	W. J. Grant.
16. St. Arvans	Monmouth	360	Miss M. Peake.
17. St. Davids	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
18. Aberystwith	Cardigan	30	J. H. Salter, B.Sc.
B			
19. Cork	Cork	100	R. A. Phillips.
20. Killarney	Kerry	100	Ven. Archdeacon Wynne, D.D.
21. Ferns	Wexford	260	G. E. J. Greene, M.D., F.L.S.
22. Glendalough	Wicklow	460	Mrs. W. Wynne.
23. Geashill	King's County	280	Rev. Canon Russell.
C			
24. Bembridge	Isle of Wight	80	C. Orchard, F.R.H.S.
25. Blandford	Dorset	270	J. C. Mansell-Pleydell, F.G.S., F.L.S.
26. Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth.
27. Bexhill-on-Sea	Sussex	10	H. Le Mesurier Dunn.
28. Muntham	Sussex	250	P. S. Godman, F.Z.S.
29. Dover	Kent	150	F. D. Campbell.
30. Wye	Kent	150	A. D. Hall.
31. Westgate-on-Sea	Kent	70	C. U. Tripp, M.A., F.R.Met.Soc.
32. Swanley	Kent	160	C. H. Hooper.
33. Chislehurst	Kent	360	Miss F. Duncan.
34. Coneyhurst	Surrey	600	J. Russell.
35. Churt Vicarage	Surrey	350	Rev. A. W. Watson.
35. Churt	Surrey	300	C. Criddle.
36. Chiddingfold	Surrey	230	R. Admiral J. P. Maclear, F.R.Met.Soc.
37. Winterfold	Surrey	580	R. Turvey.
38. Oxshott	Surrey	210	W. H. Dines, B.A., F.R.Met.Soc.
39. East Molesey	Surrey	40	Lady Jenkyns.
40. Farley	Wilts	350	Miss F. C. Henderson. Miss D. Parsons.
41. Marlborough	Wilts	480	E. Meyrick.
D			
42. Oxford	Oxford	200	F. A. Bellamy, F.R.Met.Soc.
43. Cheltenham	Gloucester	250	M. L. Evans.
44. Beckford	Gloucester	120	F. Slade, F.R.Met.Soc.
45. Watford	Herts	240	Mrs. G. E. Bishop.
46. St. Albans (The Grange)	Herts	380	Mrs. Hopkinson.
46. St. Albans (Addiscombe Lodge)	Herts	400	Miss E. F. Smith.

TABLE II.—List of Observers—*Continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
46. St. Albans (Worley Road)	Herts	300	H. Lewis.
47. Radlett	Herts	320	Miss E. M. Lubbock.
48. Berkhamsted	Herts	400	Mrs. E. Mawley.
49. Harpenden	Herts	370	J. J. Willis.
50. Ross	Hereford	210	H. Southall, F.R.Met.Soc.
51. Leominster	Hereford	220	J. H. Arkwright.
52. Evesham	Worcester	120	Rev. D. Davis, B.A.
53. Ullenhall	Warwick	400	Mrs. Coldicott.
54. Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
55. Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
56. Thurcaston	Leicester	250	Rev. T. A. Preston, M.A., F.R.Met.Soc.
57. Uppingham	Rutland	300	Miss Routh.
58. Tean	Stafford	470	Miss M. G. B. Ryves.
59. Beeston	Notts	210	G. Fellows.
60. Hodsock	Notts	60	Miss Mellish, F.R.H.S.
61. Macclesfield	Cheshire	500	J. Dale.
62. Belton	Lincoln	200	Miss F. H. Woolward.
63. Harrogate	Yorkshire	340	J. Farrah, F.R.Met.Soc.
E			
64. Wormley	Herts	120	Miss Lilian Warner.
65. Hatfield	Herts	300	T. Brown.
66. Hertford	Herts	140	W. Graveson.
67. Hitchin	Herts	230	J. E. Little, M.A.
68. Ashwell	Cambridge	260	H. G. Fordham.
69. Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
70. Lexden	Essex	90	Miss Carver.
71. Sproughton	Suffolk	30	Rev. A. Foster-Melliar.
72. Tacolneston	Norfolk	190	Miss E. J. Barrow.
73. Brundall	Norfolk	70	A. W. Preston, F.R.Met.Soc.
F			
74. Palé	Merioneth	600	T. Ruddy.
75. Penmaenmawr	Carnarvon	350	A. T. Johnson.
76. Conway	Carnarvon	100	A. T. Johnson.
77. Claughton	Lancashire	80	Mrs. Kent Green.
78. Giggleswick	Yorkshire	500	E. Peake, M.A.
79. Ambleside	Westmoreland	260	Miss M. L. Hodgson.
80. Cronkbourne	Isle of Man	110	A. W. Moore. J. Murphy.
81. Orry's Dale	Isle of Man	70	Miss C. M. Crellin.
82. Sulby	Isle of Man	80	H. S. Clarke, F.E.S.
G			
83. Clonbrock	Galway	200	Hon. R. E. Dillon.
84. Ardgillan	Dublin	210	Capt. E. R. Taylor, F.R.Met.Soc.
85. Piperstown	Louth	320	Miss E. Smith.
86. Edgeworthstown	Longford	270	J. M. Wilson, M.A.
87. Westport	Mayo	10	J. M. McBride.
88. Loughbrickland	Down	350	Rev. H. W. Lett, M.A.
89. Saintfield	Down	310	Rev. C. H. Waddell, M.A.
90. Antrim	Antrim	70	Rev. W. S. Smith.
91. Hazelbank	Londonderry	450	T. Gibson.
92. Ballynagard	Londonderry	30	Miss A. M. Campbell.
93. Ramelton	Donegal	200	Miss K. Swiney.

TABLE II.—List of Observers—*Continued.*

Station.	County.	Height above Sea-level.	Observer.
H		Ft.	
94. New Galloway	Kirkcudbright	450	T. R. Bruce.
95. Tynron	Dumfries	520	J. Shaw.
96. Thornhill	Dumfries	300	J. Fingland.
97. Jardington	Dumfries	100	J. Rutherford.
98. Helensburgh	Dumbarton	100	Miss Muirhead.
I			
99. Doddington	Lincoln	90	Rev. R. E. Cole.
100. Great Cotes	Lincoln	30	J. Cordeaux.
101. East Layton	Yorks (N. R.)	570	Mrs. E. O. Maynard Proud.
102. Durham	Durham	350	H. J. Carpenter.
103. Corbridge-on-Tyne	Northumberland	200	A. W. Price.
104. Cambois	Northumberland	20	S. Dunnett.
105. Lilliesleaf	Roxburgh	530	Miss O. R. Carre.
J			
106. Kirriemuir	Forfar	250	T. M. Nicoll.
107. Aberdeen	Aberdeen	40	P. Harper.
108. Newmill	Banff	350	J. Ingram.
109. Lhanbryde	Elgin	50	J. Cruikshank. W. Taylor.
K			
110. Beauly	Inverness	60	A. Birnie.
111. Inverbroom	Ross	50	J. A. Fowler.
112. Dingwall	Ross	10	J. P. Smith, M.D.

The numbers before the names of the stations refer to their position on the map of the stations (Plate I.)

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1896.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse-chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A													
Marazion	39	55	...	69	...	106	108	136	137	174	...	168	242
Mawnan	30	70	91	59	100	113	118	...	137	166	...	...	...
Falmouth	35	36	95	57	106	103	108	...	138	150	...	...	231
Liskeard	40	...	91	76	...	120	114	...	...	...	...	...	...
Tiverton	28	69	79	83	97	111	115	142	137	150	...	...	267
Westward Ho	27	...	...	84	104	111	130	142	...	*194*	...	181	...
Barnstaple	27	45	82	76	76	115	120	138	138	178	196	163	254
Sidcot	17	52	80	89	96	115	128	135	152	158	...	...	*299*
Long Ashton	36	62	85	84	99	..	115	...	129	...	...	...	262
Clifton	34	43	...	87	...	116	115	134	149	...	192	...	...

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1896—*Continued.*

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse-chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.
Cardiff	30	42	...	91	94	108	113	...	...	...	...	...
Castleton	30	43	72	81	96	97	118	133	145	165	191	164
Bridgend	...	...	*100*	...	...	...	131	...	155	...	...	...
Bassaleg	36	38	80	79	...	108	114	129	138	156	...	168
St. Arvans	21	68	73	86	104	113	124	142	143	150	179	...
St. Davids	...	*104*	...	95	...	110	119	157	...	168	...	174
Aberystwith	14	54	75	63	...	...	121	...	...	...	...	...
B												
Cork	26	50	54	71	...	100	106	*114*	140	173	...	176
Killarney	6	30	57	55	96	92	101	132	136	180	...	172
Ferns	37	52	79	68	...	108	108	134	135	177	181	181
Glendalough	9	51	...	74	88	108	112	126	138	169	...	178
Geashill	4	41	71	...	100	107	128	133	146	159	...	182
C												
Bembridge	27	28	...	81	104	109	116	124	147	160	...	...
Blandford	18	73	82	84	117	114	131	133	145	156	166	183
Buckhorn Weston	26	62	84	84	90	120	121	...	145	150	...	171
Bexhill-on-Sea	37	78	78	64	106	108	118	127	*127*	...	...	...
Muntham	22	54	75	72	104	124	121	132	152	159	...	182
Dover	...	...	...	...	...	120	136	...	157	169	...	...
Wye	39	60	81	85	...	124	132	...	...	...	...	...
Westgate-on-Sea	...	...	...	*101*	*120*	125	121	140	156	157	187	195
Swanley	8	62	77	86	113	125	125	*152*	152	...	...	172
Chislehurst	6	65	72	81	111	119	121	143	153	173	191	185
Coneyhurst	25	70	84	92	...	128	122	139	144	...	177	*162*
Churt Vicarage	14	74	81	87	112	122	121	142	154	165	179	190
Churt	2	*86*	...	...	105	115	117	131	...	...	*151*	192
Chiddingfold	33	56	75	86	99	116	124	138	149	157	184	172
Winterfold	44	61	63	80	...	128	...	...	139	...	...	...
Oxshott	47	...	86	94	108	122	119	...	155	162	...	...
East Molesey	29	61	94	84	103	116	119	136	151	...	197	175
Farley	27	69	67	84	98	111	119	132	142	...	...	...
Marlborough	21	54	70	91	109	120	124	138	145	165	186	175
D												
Oxford	50	52	...	97	87	117	117	124	142	...	...	...
Cheltenham	32	40	75	82	110	117	126	140	148	173	194	190
Beckford	39	52	76	76	104	109	116	122	140	153	177	169
Watford	22	...	90	95	106	126	127	142	156	...	192	191
St. Albans (The Grange)	16	...	74	85	102	122	122	142	153	...	...	...
St. Albans (Addiscombe Lodge)	28	44	...	74	108	125	126	135	153	167	190	...
Radlett	41	...	...	90	...	116	122	142	153	...	...	...
Berkhamsted	51	50	91	84	108	128	134	136	149	171	190	170
Harpenden	18	73	84	85	105	112	121	142	151	164	...	...
Ross	19	39	83	81	93	114	110	...	...	...	...	...
Leominster	34	84	72	84	...	121	126	...	...	...	...	175
Evesham	28	51	56	82	97	117	120	120	145	172	...	...
Ullenhall	42	62	80	79	...	121	118	128	154	...	185	196
Northampton	51	61	79	87	102	120	122	146	159	176	187	189
Churchstoke	53	66	85	96	*127*	129	131	139	152	181	...	...

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1896—*Continued.*

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse-chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
urcaston . .	47	49	89	101	99	125	120	140	150	155	189	191	276
pingham . .	40	73	82	84	109	128	121	156	150	176	181	...	...
an . . .	32	52	...	104	117	133	134	...	...	...	...	...	...
ston . .	32	53	...	100	...	124	124	155	157	161	*153*	...	...
dsock . .	9	63	77	86	100	115	123	148	154	172	186	166	260
cclesfield .	58	78	113	117	137	131	132	155	162	186	188	191	276
ton . .	38	56	77	93	112	123	122	...	155	...	...	...	...
rrogate . .	12	54	85	97	109	129	133	143	160	168	187	180	270
E													
rmley . .	12	60	71	83	116	127	116	146	148	...	...	...	...
tfield . .	40	83	97	94	...	111	120	147	148	...	188	...	...
rtford . .	13	40	68	68	97	117	107	135	149	180	187	184	268
tchin . .	19	38	78	77	101	120	113	134	143	...	...	174	...
well . .	19	64	...	89	...	...	119	...	154	...	...	...	255
cking . .	27	72	...	99	106	116	134	151	151	165	...	...	246
xden . .	6	...	82	82	98	115	122	...	154	...	...	...	257
roughton . .	16	45	75	82	109	123	125	133	153	...	...	...	268
colneston .	36	67	85	...	...	111	122	...	...	...	...	...	...
ndall . .	33	82	82	96	94	127	128	137	156	194	...	177	275
F													
lé	45	71	94	88	124	130	132	141	151	192	173	188	*298*
maenmawr .	40	70	...	72	...	...	...	...	...	...	...	...	...
nway . .	...	...	...	...	...	...	115	129	147	...	...	190	...
ughton . .	45	64	83	95	119	...	126	152	...	178	188	...	...
gleswick .	33	45	93	103	*131*	131	134	144	...	...	...	...	...
bleside . .	20	44	69	99	113	128	129	145	145	174	*156*	169	...
nkbourne .	...	52	...	...	123	120	129	...	...	...	...	...	276
ry's Dale . .	18	69	...	98	...	110	122	141	149	...	...	160	264
G													
nbrock . .	32	...	60	71	...	114	114	141	142	...	...	...	...
dgillan . .	*70*	*18*	...	85	...	111	118	...	...	...	...	...	...
erstown . .	41	46	...	73	...	104	125	...	144	195	...	170	241
geworthstown .	...	...	...	89	...	123	118	145	146	...	...	...	...
stport . .	33	...	54	88	...	98	112	...	...	...	...	...	...
ughbrickland .	30	78	89	92	...	122	123	151	151	184	...	190	258
ntfield . .	46	64	83	85	...	114	125	...	151	...	...	173	266
trim . .	47	82	64	83	...	126	128	150	145	180	...	197	275
zelbank . .	41	67	82	96	...	125	127	141	145	207	...	...	...
lynagard .	...	...	...	...	...	111	118	...	...	...	...	195	...
melton . .	52	...	...	87	*161*	117	123	146	147	209	...	167	...
H													
w Galloway .	33	...	107	108	...	...	134	150	153	...	...	...	...
aron . .	42	69	98	106	...	132	133	...	151	...	...	...	...
ornhill . .	28	54	95	101	122	131	130	...	...	...	...	...	...
dington . .	41	76	85	105	...	125	131	...	147	178	181	...	...
lensburgh .	33	59	93	92	119	125	121	145	150	...	194	...	...

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1896—*Continued.*

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse-chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
I													
Doddington . .	39	76	85	94	109	124	127	149	151	...	...	172	...
East Layton .	58	65	99	100	121	128	134	165	160	...	...	...	292
Durham . .	...	76	84	104	...	133	135	167	167	...	167	...	...
Corbridge-on-Tyne	19	68	83	97	...	142	131	...	...	...	...	...	260
Cambois . .	46	*39*	75	...	132	133	129	...	152	196	191	202	...
Lilliesleaf . .	47	60	...	106	...	140	134	152	151	...	...	...	...
J													
Kirriemuir . .	...	64	...	102	*152*	133	132	143	149	196	174	195	...
Aberdeen . .	...	67	112	...	...	129	130	*188*	...	...	202	...	...
Newmill . .	32	45	81	99	121	130	137	153	157	196	190	182	281
Lhanbryde . .	57	53	87	...	121	126	128	144	150	...	...	...	...
K													
Beauly . .	41	46	99	109	...	130	129	154	137	...	205	...	...
Inverbroom . .	27	48	112	87	...	137	151	144	148	...	...	...	...
Dingwall . .	26	46	82	88	114	128	129	142	143	...	192	...	289

The dates in *italics* have not been taken into consideration when calculating the means given in Table IV.

OBSERVERS' NOTES.

DECEMBER 1895.—*Mawnan* (A)—Scarcely any berries on the holly, but those on the ivy were very numerous. *East Molesey* (C)—Very mild. Thrushes singing all the month. *Watford* (D)—Very few berries on either holly or ivy.

JANUARY 1896.—*Mawnan* (A)—29th. Veronica in full flower. It did not blossom in the summer owing to its having been cut back by the bitter winds of the previous winter and spring. 30th. Heliotropes, verbenas, and calceolarias still alive out of doors. *Falmouth* (A)—5th. Crimson rhododendron in full bloom at Boslowick. *Long Ashton* (A)—19th. I measured some elder leaves and they were 1½ inch long. *Bridgend* (A)—19th. A solitary primrose in bloom in a wood. *St. Arvans* (A)—24th. Winter aconite in flower. *Geashill* (B)—7th. Winter aconite in flower. *Bembridge* (C)—Self-sown potatoes quite a foot high. Cutting brocoli all the month. *Addlestone* (C)—24th. Thrush and blackbird building. *Chiselhurst* (C)—19th. Daphne mezereum in flower. *Coneyhurst* (C)—11th. First yellow crocus. *Churt Vicarage.* (C)—28th. First yellow crocus. *Watford* (D)—13th. Winter aconite in flower. *St. Albans* (*Addiscombe Lodge*) (D)—20th. Creeping and bulbous buttercups in flower. *Berkhamsted* (D)—9th. Winter aconite in flower, 3 days earlier than in any of the previous 7 years. *Ross* (D)—1st. Great Tit singing, the earliest date in 15 years, with the exception of December 30, 1892. *Cronkbourne* (F)—2nd. Winter aconite in flower. *Piperstown* (G)—16th. Primrose in flower. *Lilliesleaf* (I)—Winter aconite in flower

TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1896, AND THEIR VARIATIONS FROM THE SIX YEARS' AVERAGE (1891-6).

PLANTS.	A England, S.W.			B Ireland, S.			C England, S.			D England, Mid.		
	1896.	Average for Six Years.	Variation from Average.	1896.	Average for Six Years.	Variation from Average.	1896.	Average for Six Years.	Variation from Average.	1896.	Average for Six Years.	Variation from Average.
Hazel	30	40	−10	16	*36*	−20	25	40	−15	36	44	−8
Coltsfoot	52	58	−6	45	*57*	−12	62	61	+1	58	68	−10
Wood Anemone	82	85	−3	65	*81*	−16	78	84	−6	82	88	−6
Blackthorn	79	92	−13	67	*93*	−26	83	98	−15	90	102	−12
Garlic Hedge Mustard	97	104	−7	95	*106*	−11	106	111	−5	106	113	−7
Horse-chestnut	110	118	−8	103	*117*	−14	119	123	−4	122	127	−5
Hawthorn	118	126	−8	111	*123*	−12	123	127	−4	124	130	−6
White Ox Eye	139	142	−3	131	*137*	−6	135	139	−4	140	145	−5
Dog Rose	142	151	−9	139	*148*	−9	149	154	−5	152	157	−5
Black Knapweed	161	170	−9	172	*168*	+4	161	167	−6	170	174	−4
Harebell	190	186	+4	181	*177*	+4	183	179	+4	187	188	−1
Greater Bindweed	170	181	−11	178	*179*	−1	181	185	−4	183	188	−5
Ivy	251	264	−13	240	*263*	−23	263	268	−5	267	270	−3
Mean for the 13 Plants	125	132	−7	119	*130*	−11	128	133	−5	132	138	−6

PLANTS.	E England, E.			F England, N.W.			G Ireland, N.			H Scotland, W.		
Hazel	22	40	−18	34	46	−12	40	52	−12	35	50	−15
Coltsfoot	61	61	Av.	59	67	−8	67	74	−7	65	82	−17
Wood Anemone	80	87	−7	85	93	−8	72	85	−13	96	102	−6
Blackthorn	86	99	−13	93	104	−11	85	100	−15	102	110	−8
Garlic Hedge Mustard	103	109	−6	122	123	−1	...	*117*	...	121	*123*	−2
Horse-chestnut	119	122	−3	120	126	−6	115	127	−12	128	135	−7
Hawthorn	121	127	−6	127	134	−7	121	134	−13	130	143	−13
White Ox Eye	140	143	−3	142	148	−6	146	151	−5	148	*154*	−6
Dog Rose	151	153	−2	148	157	−9	146	161	−15	150	163	−13
Black Knapweed	180	177	+3	181	181	Av.	195	202	−7	178	*185*	−7
Harebell	188	*183*	+5	181	180	+1	...	*188*	...	188	*194*	−6
Greater Bindweed	178	187	−9	177	186	−9	182	*190*	−8	...	*196*	...
Ivy	262	261	+1	270	280	−10	260	*274*	−14	...	*280*	...
Mean for the 13 Plants	130	135	−5	134	140	−6	130*	141*	−11*	121*	*131**	−10*

PLANTS.	I England, N.E.			J Scotland, E.			K Scotland, N.			British Isles.		
Hazel	42	53	−11	45	*52*	−7	31	*49*	−18	32	46	−14
Coltsfoot	69	70	−1	57	*73*	−16	47	*70*	−23	58	67	−9
Wood Anemone	85	96	−11	93	*97*	−4	98	*94*	+4	83	90	−7
Blackthorn	100	110	−10	101	*109*	−8	95	*106*	−11	90	102	−12
Garlic Hedge Mustard	121	*121*	Av.	121	*122*	−1	114	*118*	−4	109	*115*	−6
Horse-chestnut	133	138	−5	130	*133*	−3	132	*130*	+2	121	127	−6
Hawthorn	132	140	−8	132	*139*	−7	136	*136*	Av.	125	133	−8
White Ox Eye	158	158	Av.	147	*153*	−6	147	*150*	−3	143	147	−4
Dog Rose	156	167	−11	152	*164*	−12	143	*161*	−18	148	158	−10
Black Knapweed	196	198	−2	196	*184*	+12	...	*181*	...	179	181	−2
Harebell	179	188	−9	189	*193*	−4	199	*190*	+9	186	*186*	Av.
Greater Bindweed	187	*194*	−7	189	*195*	−6	...	*192*	...	181	*188*	−7
Ivy	276	*278*	−2	281	*279*	+2	289	*276*	+13	266	*272*	−6
Mean for the 13 Plants	141	147	−6	141	*146*	−5	130*	*135**	−5*	132	139	−7

* For 11 Plants.

+ indicates thė number of days later than the average date.
− ,, ,, ,, earlier ,, ,,
Av. ,, average date.
The dates in *italics* are approximate averages.

FEBRUARY.—*Marazion* (A)—Wild-fowl of all kinds have been very scarce during the winter. *Barnstaple* (A)—28th. The number of species of wild plants observed in flower in the same or in similar habitats up to this date has been as follows:—35 in 1894, 11 in 1895, and 28 in 1896. *Sidcot* (A)—A plum tree has been sparingly in flower during most of the latter half of the month. *Long Ashton* (A)—1st. Cydonia Japonica covered with blossom. *Bassaleg* (A)—First daffodil in flower. *Cork* (B)—28th. Gathered a ripe wild strawberry. *Bembridge* (C)—Vegetables of all kinds very plentiful. *Bexhill-on-Sea* (C)—27th. A thrush's nest found with eggs in it. *Addlestone* (C)—Tillage for cereals, etc., at the end of month as advanced as it was at end of April in 1895. In fact a more perfect seed-time and seed-bed could not be imagined. 14th. Germander Speedwell in flower. *Swanley* (C)—21st. Frog spawn. *Churt* (C)—Although such a mild quarter, the absence of sunshine has greatly helped to retard the otherwise early appearance of wild flowers generally. *Cheltenham* (D)—2nd. Primroses in bloom. *Ambleside* (F)—This has been a remarkable year for catkins of all kinds. The alders, birches, hazels, and poplars have been a marvellous sight—alder catkins 4 and 5 inches long. *Hazelbank* (G)—Throughout the winter snipe and woodcock were very scarce. *New Galloway* (H)—10th. Yellow crocus in flower. *Newmill* (J)—Although the winter has been so mild, the want of sunshine has helped to keep back the flowering season.

MARCH.—*Marazion* (A)—The broccoli crop has been late and of inferior quality. *Mawnan* (A)—18th. Pear and plum in blossom. *Falmouth* (A)—16th. Found valerian, veronica, herb-robert, primrose, and greater stitchwort in flower. *St. Arvans* (A)—8th. Elm in blossom. *Killarney* (B)—1st. Peas 18 ins. high, early potatoes above ground, currants in flower. 14th. Plague of small snails. *Geashill* (B)—4th. Cowslip in flower. *Bembridge* (C)—15th and 19th. Early potatoes and asparagus cut off by frost. 27th. Cut first dish of asparagus out of doors, the earliest date recorded. *Addlestone* (C)—Grass growing rapidly. 3rd. Frog spawn. *Swanley* (C)—24th. Damson in flower. *Chislehurst* (C)—21st. First wryneck. 25th. First chiffchaff. *Churt Vicarage* (C)—24th. Wryneck first seen and heard—very early. *East Molesey* (C)—Blackthorn in leaf and flower at the same time at the end of month. *Leominster* (D)—23rd. Chiffchaff first heard. *Evesham* (D)—10th. First redstart. 23rd. First chiffchaff. 27th. First wryneck. *Macclesfield* (D)—Slugs very numerous. 18th. Pansies and primroses in flower. *Newmill* (J)—2nd. Frog spawn first seen.

APRIL.—*St. Arvans* (A)—12th. Pear and plum in blossom. *St. Davids* (A)—Gorse blossom unusually abundant. *Killarney* (B)—30th. Young laurel leaves killed by frost. *Glendalough* (B)—Greenfly a great plague. 11th. A violent storm from the North-west did much damage to the young foliage, burning up the leaves, especially those of the birch, also the young shoots of the spruce and silver fir. *Bembridge* (C)—23rd. Frost cut down early potatoes, etc. *Swanley* (C)—5th. Gooseberry in flower. 10th. Red currant in flower. 12th. Cherry in flower. 20th. Apple in flower. *Chislehurst* (C)—10th. First willow-wren. 23rd. First redstart. 26th. First white-throat. Trees terribly blighted. Abundant blossom on all flowering shrubs. *Coneyhurst* (C)—20th. Swift first seen. *Oxford* (D)—30th. Leaves of dahlias, sycamore, and ferns destroyed by frost. *St. Albans, Worley Road* (D)—17th. Wryneck heard. 27th. House-martin first seen. *Evesham* (D)—The following migrants appeared on the dates named. 16th. Tree-pipit and yellow wagtail. 17th. Nightingale. 18th. Cuckoo, willow-wren, white-throat, and garden warbler. 19th. Sand-piper and sand-martin. 21st. Black-cap. 25th. Grasshopper-warbler. 27th Corncrake. 29th. Lesser white-throat. *Tean* (D)—18th. Corncrake heard. *Beeston* (D)—25th. Great bloom on apples, pears, and wall fruit. 30th.—Oaks in leaf very much before the ash; oaks in great bloom. *Wormley* (E)—The

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1896.

STATION.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A											
Marazion	2	111	110	...	...	274	80	98	59	124	177
Mawnan	2	...	110	...	...	...	28	...	91	111	157
Falmouth	...	111	97	...	133	...	76	97	106	127	83
Liskeard	...	92	112	...	143	316	57	...	83	113	83
Tiverton	22	102	114	...	...	...	...	...	...	...	...
Westward Ho . . .	2	112	109	...	...	...	90	90	*122*	*146*	*188*
Sidcot	...	102	108	114	141	274	89	...	...	...	...
Long Ashton . . .	2	93	107	...	110	311	19	79	93	...	...
Clifton	...	116	116	...	...	...	...	...	...	...	...
Penarth	...	...	...	...	...	...	70	116	85	104	149
Cardiff	...	101	112	...	...	...	19	97	79	...	...
Castleton	17	102	112	...	137	301	18	74	108	98	131
Bridgend	...	*121*	111	...	...	290	...	...	...	...	...
Bassaleg	17	110	111	112	129	285	43	56	95	97	127
St. Arvans . . .	22	103	109	...	137	297	19	115	83	123	134
St. Davids . . .	*56*	99	113	...	...	...	69	...	98	126	156
B											
Cork	20	110	125	...	...	...	...	...	100	110	124
Killarney	...	113	117	...	...	...	73	101	100	112	127
Ferns	11	100	114	...	...	272	85	89	97	109	106
Glendalough . . .	...	101	110	...	125	285	32	109	111	117	...
Geashill	2	100	122	...	135	*262*	...	...	114	124	162
C											
Bembridge . . .	2	94	108	114	...	319	58	114	100	128	163
Blandford	2	105	108	109	109	...	76	127	82	101	150
Buckhorn Weston . .	3	102	91	110	122	294	19	...	...	101	153
Bexhill-on-Sea . . .	2	107	102	106	124	313	41	85	89	127	141
Muntham	16	104	106	114	135	311	73	...	96	113	...
Dover	...	114	...	...	...	332	...	...	...	...	...
Wye	...	108	109	113	127	295	...	...	119	...	...
Westgate-on-Sea . .	...	104	114	113	115	...	...	...	*140*	...	141
Swanley	...	...	109	117	...	...	...	...	111	...	175
Chislehurst . . .	2	114	109	115	131	302	50	69	111	135	163
Coneyhurst . . .	37	108	105	115	150	281	53	69	111	...	...
Churt Vicarage . . .	2	106	109	111	140	318	30	*127*	108	125	150
Churt	2	113	104	111	137	285	35	...	103	129	...
Chiddingfold . . .	...	111	103	98	...	292	...	118	96	109	145
Winterfold . . .	34	105	104	110	...	...	33	40	...	...	...
Oxshott	30	116	109	113	...	310	...	...	...	...	...
East Molesey . . .	2	106	111	*126*	...	269	39	66	108	135	...
Farley	...	111	106	111	...	...	40	112	...	...	...
Marlborough . . .	26	110	110	...	135	300	...	...	84	127	156
D											
Oxford	16	109	110	...	...	...	...	...	112	116	...
Cheltenham . . .	16	100	109	112	145	291	40	103	110	138	173
Beckford	2	109	110	111	132	...	17	114	101	113	146
Watford	15	113	119	120	153	290	...	...	...	...	...
St. Albans (The Grange) .	3	111	101	114	...	...	39	19	72	...	...
St. Albans (Addisc'be Lodge)	19	117	108	...	...	...	44	79	98	130	...

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1896—*Continued.*

STATION.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
St. Albans (Worley Road) .	...	117	103	112	152	325	...	...	...	...	...
Radlett	*125*	117	110	...	...	...	...	114	117	...	...
Berkhamsted . . .	12	100	109	109	109	296	40	110	110	136	146
Harpenden . . .	15	115	111	117	...	...	...	117	111	139	...
Ross	19	110	113	114	148	...	19	...	...	115	...
Leominster . . .	20	102	110	124	144	...	20	110	96	108	84
Evesham	17	106	109	108	127	...	42	94	...	110	...
Ullenhall	34	110	110	115	135	280	20	112	84	116	...
Churchstoke . . .	33	112	114	...	...	...	...	121	110	113	163
Thurcaston . . .	...	...	...	...	...	...	...	113	...	...	...
Uppingham . . .	19	104	110	112	...	...	27	68	99	131	...
Tean	7	100	110	...	...	...	41	...	115	127	130
Beeston	17	106	112	*134*	...	296	...	106	97	...	...
Hodsock	4	102	110	117	137	309	18	100	83	129	...
Macclesfield . . .	18	125	120	...	...	277	...	...	...	...	...
Belton	...	108	111	114	134	...	36	68	112	133	...
Harrogate	33	107	109	...	138	300	71	40	...	...	...
E											
Wormley	2	113	106	114	...	...	19	84	109	130	...
Hatfield	18	111	109	113	...	...	...	...	*128*	128	...
Hitchin	...	106	108	108	...	...	17	114	...	113	...
Ashwell	...	114	115	112	136	295	...	82	...	...	...
Bocking	...	114	113	113	...	...	...	...	...	...	...
Lexden	9	111	110	113	*161*	289	50	85	109	124	161
Sproughton . . .	2	113	108	117	135	316	40	97	99	130	130
Tacolneston . . .	2	110	112	117	...	...	...	...	113	116	...
Brundall	...	...	108	...	...	...	...	...	...	...	...
F											
Palé	20	74	112	...	130	264	43	112	112	132	187
Conway	...	106	111	...	...	303	...	...	...	...	...
Claughton	...	114	116	...	119	...	...	...	...	...	...
Giggleswick . . .	41	101	122	...	136	...	...	...	115	...	...
Ambleside . . .	38	119	93	...	...	288	83	111	109	115	109
Cronkbourne . . .	6	101	123	...	...	280	2	100	119	...	103
Orry's Dale . . .	7	110	112	...	...	271	...	108	108	...	...
Sulby	30	110	112	...	...	275	37	58	116	...	142
G											
Clonbrock . . .	2	109	109	...	122	...	*115*	95	112	113	141
Ardgillan	18	106	112	...	...	330	...	77	117	118	...
Piperstown . . .	2	106	113	...	...	278	37	111	117	111	108
Edgeworthstown . .	3	107	113	...	*156*	284	101	117	109	121	...
Westport	40	111	122	...	...	270	...	131	...	...	...
Loughbrickland . .	5	100	117	...	...	271	52	39	108	124	...
Saintfield	2	106	112	...	...	287	85	...	109	117	...
Antrim	24	107	*139*	137	...	274	...	117	111	127	...
Hazelbank . . .	7	116	121	...	...	...	...	121	111	125	175
Ballynagard . . .	2	104	112	...	...	...	...	...	124	127	172
Ramelton	2	105	113	...	...	...	27	130	112	128	...
H											
New Galloway . . .	39	112	114	...	...	...	33	109	126	...	...

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1896—*Continued.*

STATION.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
Tynron	45	...	115	...	...	...	71	121	125	...	...
Thornhill	...	109	...	...	...	...	71	119	...	...	...
Jardington	27	120	121	...	139	...	...	116	106	...	166
Helensburgh	16	106	118	...	...	...	89	126	123	...	...
I											
Great Cotes	2	111	113	128	135	293	...	...	...	...	...
East Layton	38	116	122	...	132	278	36	100	101	*147*	...
Durham	25	116	124	...	...	291	81	126	106	131	...
Corbridge-on-Tyne	46	117	122	...	...	265	89	119	...	...	...
Cambois	...	111	113	...	...	...	83	...	...	...	...
Lilliesleaf	44	...	123	147	...	...	40	...	128	...	...
J											
Kirriemuir	...	115	123	...	...	274	43	125	...	...	...
Aberdeen	2	103	*132*	...	134	269	96	125	103	...	...
Newmill	...	*131*	115	...	...	258	38	48	109	133	179
Lhanbryde	63	...	125	...	...	...	28	95	114	...	...
K											
Beauly	69	119	123	...	167	254	41	112	127	129	...
Inverbroom	30	*156*	114	...	145	...	30	36	119	...	...
Dingwall	18	116	116	...	156	261	57	124	126	...	187
Mean Dates for the British Isles in 1896	17 Jan. 17th.	108 Apl. 17th	112 Apl. 21st	115 Apl. 24th	135 May 14th	290 Oct. 16th	48 Feb. 17th	97 Apl. 6th	105 Apl. 14th	121 Apl. 30th	144 May 23rd
Mean Dates for 1891-6	Feb. 2nd.	Apl. 17th	Apl. 20th	Apl. 21st.	May 13th	Oct. 13th	Feb. 28th	Apl. 7th	Apl. 11th	May 4th	June 7th

The dates in *italics* have not been taken into consideration when calculating the means for the British Isles.

mild winter made less difference in the early flowering of plants than one would have expected. *Sproughton* (E)—26th. Nightingale arrived here decidedly later than usual. *Conway* (F)—28th. Swift first seen. *Giggleswick* (F)—Plovers not exceptionally early, but conditions so favourable for eggs at the end of March that nearly 4000 were sent from Settle at the beginning of the month. *Orry's Dale* (F)—23rd. Corncrake first heard. *Sulby* (F)—21st. Corncrake first heard. *Westport* (G)—26th. Corncrake first heard. *Loughbrickland* (G)—18th. Corncrake first heard. *New Galloway* (H)—20th. Apple in blossom. 23rd. Pear in blossom.

MAY.—*Marazion* (A)—7th. Swift first seen. *Mawnan* (A)—22nd. Gathered several ripe strawberries. *Tiverton* (A)—Haymaking general during the last week of this month. 21st. Wild strawberries ripe. *Barnstaple* (A)—31st. The number of species of wild plants observed in flower up to this date—290 against 222 in 1895. *Clifton* (A)—One of the most striking features of the spring has been the great abundance of lepidopterous larvæ, the winter moth,

TABLE VI.—ESTIMATED YIELD OF FARM CROPS IN 1896.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A S.W.	**C** S.	**D** Mid.	**E** E.	**F** N.W.	**I** N.E.	**H** W.	**J** E.	**K** N.	**B** and **G** S. and N.	
Wheat	Av.	O. Av.	O. Av.	O. Av.	Av.	O. Av.	Av.	O. Av.	...	O. Av.	O. Av.
Barley	U. Av.	U. Av.	U. Av.	U. Av.	Av.	O. Av.	Av.	O. Av.	...	Av.	Av.
Oats	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	Av.	...	U. Av.	U. Av.
Corn Harvest began, average Date	201 (July 19)	200 (July 18)	205 (July 23)	205 (July 23)	219 (Aug. 6)	219 (Aug. 6)	233 (Aug. 20)	231 (Aug. 18)	244 (Aug. 31)	222 (Aug. 9)	218 (Aug. 5)
Beans	U. Av.	U. Av.	U. Av.	U. Av.	Av.	Av.	Av.	O. Av.	...	...	U. Av.
Peas	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	...	O. Av.	...	...	U. Av.
Potatoes	U. Av.	Av.	Av.	U. Av.	O. Av.	Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Turnips	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	O. Av.	Av.	...	Av.	U. Av.
Mangolds	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	...	...	U. Av.	U. Av.
Hay (Permanent Pasture)	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	O. Av.	Av.	...	U. Av.	U. Av.
Hay (Clover, etc.)	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	O. Av.	Av.	...	U. Av.	U. Av.

The variations from the average for the above crops have been obtained from the returns which appeared in the *Agricultural Gazette*, July 27, 1896.

TABLE VII.—ESTIMATED YIELD OF FRUIT CROPS IN 896.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A S.W.	**C** S.	**D** Mid.	**E** E.	**F** N.W.	**I** N.E.	**H, J,** and **K** W. E. and N.	**B** and **G** S. and N.	
Apples	U. Av.	U. Av.	U. Av.	Av.	U. Av.	Av.	Av.	O. Av.	U. Av.
Pears	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Plums	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	O. Av.	Av.	U. Av.
Raspberries	O. Av.	Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Currants	O. Av.	Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Gooseberries	O. Av.	Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Strawberries	Av.	O. Av.	Av.	Av.	Av.	O. Av.	O. Av.	Av.	O. Av.

Symbols:—O. = Over. U. = Under. Av. = Average. This Table has been compiled from returns which appeared in the *Gardeners' Chronicle*, Aug. 1, 1896.

TABLE VIII.—APPROXIMATE VARIATIONS FROM THE AVERAGE IN MEAN TEMPERATURE, RAINFALL, AND SUNSHINE, 1895-6.

WINTER 1895-96.

Temperature.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December . .	+0·5	+0·3	+0·5	−0·5	−0·3	−0·8	−1·3	0·0	−0·3	−1·0	−0·3
January . .	+1·8	+2·6	+2·2	+3·0	+2·4	+2·6	+3·0	+2·8	+2·6	+2·8	+2·0
February . .	+0·8	+3·0	+0·5	+0·8	+0·3	+1·5	+3·3	+3·3	+1·8	+4·0	+4·5
Winter . .	+1·0	+2·0	+1·1	+1·1	+0·8	+1·1	+1·7	+2·0	+1·4	+1·9	+2·1
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December . .	+1·2	+2·1	−0·3	−0·5	−0·8	−0·1	+0·7	−0·9	−1·0	+0·4	−0·1
January . .	−2·6	−2·5	−2·0	−1·6	−0·7	−1·4	−1·3	−2·8	−0·8	−1·4	+0·1
February . .	−2·3	−1·2	−1·6	−1·3	−1·1	−0·6	−0·9	−1·4	−1·1	−1·5	0·0
Winter . .	−3·7	−1·6	−3·9	−3·4	−2·6	−2·1	−1·5	−5·1	−2·9	−2·5	0·0
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December . .	−14	0	− 6	− 1	+ 1	− 9	− 8	− 7	− 8	− 6	+ 3
January . .	−10	−21	−18	−12	−13	− 8	−12	− 8	+ 5	+ 6	− 8
February . .	−13	− 9	+ 3	− 1	+ 2	−20	−12	−34	−27	−19	−22
Winter . .	−37	−30	−21	−14	−10	−37	−32	−49	−30	−19	−27
SPRING 1896. *Temperature.*											
	°	°	°	°	°	°	°	°	°	°	°
March . .	+3·8	+2·5	+4·3	+3·5	+3·3	+2·0	+1·3	+1·8	+2·5	+1·5	+1·3
April . .	+1·4	+1·6	+1·0	+1·2	+0·4	+1·2	+1·8	+1·6	+2·4	+2·8	+1·4
May . .	+3·8	+3·5	+2·0	+2·3	+0·5	+2·8	+4·0	+4·0	+1·8	+4·8	+3·5
Spring . .	+3·0	+2·5	+2·4	+2·3	+1·4	+2·0	+2·4	+2·5	+2·2	+3·0	+2·1
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March . .	+1·7	+2·2	+1·1	+0·9	+1·4	+2·5	+2·1	+2·5	+0·6	+0·1	+3·0
April . .	−1·8	−1·9	−1·5	−1·2	−0·6	−0·5	−0·4	−1·0	−1·3	−0·9	+1·1
May . .	−2·0	−2·1	−1·5	−1·5	−1·3	−1·6	−1·2	−1·7	−1·1	−1·0	−1·0
Spring . .	−2·1	−1·8	−1·9	−1·8	−0·5	+0·4	+0·5	−0·2	−1·8	−1·8	+3·1
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March . .	−37	−26	−25	−15	−22	−16	−12	− 2	− 3	+ 8	0
April . .	− 1	−28	−34	+ 4	0	+26	−22	− 1	+16	+18	−40
May . .	+87	+62	+35	+32	+10	+68	+59	+76	+11	+44	+60
Spring . .	+49	+ 8	−24	+21	−12	+78	+25	+73	+24	+70	+20

+ indicates above the average, − below it,

TABLE VIII.—VARIATIONS FROM THE AVERAGE—*Continued.*

SUMMER 1896.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
June . .	+3·5	+2·5	+3·8	+3·5	+3·8	+3·5	+3·0	+2·3	+3·0	+1·8	+1·0
July . .	+1·4	+0·4	+2·2	+1·0	+1·2	+0·4	−0·2	−0·4	+1·0	−0·2	−0·4
August . .	−1·5	−0·5	−1·8	−2·3	−2·3	−1·8	−1·5	−1·0	−1·8	−1·5	−1·8
Summer . .	+1·1	+0·8	+1·4	+0·7	+0·9	+0·7	+0·4	+0·3	+0·7	0·0	−0·4
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June . .	−0·3	+0·1	+0·3	+0·3	0·0	+0·1	+0·9	+0·5	−0·1	+0·9	+0·7
July . .	−1·3	+1·4	−1·6	−1·3	−1·7	+0·2	+2·0	+1·5	−0·6	+0·3	−0·2
August . .	−1·5	−1·2	−0·4	−0·9	−0·1	−0·7	−0·6	−0·8	−0·8	−1·2	+0·6
Summer . .	−3·1	+0·3	−1·7	−1·9	−1·8	−0·4	+2·3	+1·2	−1·5	0·0	+1·1
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June . .	+29	+17	+44	+25	+41	+17	− 8	+ 7	+19	−28	−38
July . .	+38	+ 5	+49	+22	+41	+18	−25	−33	+20	+ 6	− 8
August . .	+ 6	− 8	−27	−32	−41	−17	− 1	+26	−32	− 8	− 2
Summer . .	+73	+14	+66	+15	+41	+18	−34	0	+ 7	−30	−48
AUTUMN 1896. *Temperature.*											
	°	°	°	°	°	°	°	°	°	°	°
September .	0·0	+0·3	+0·5	+0·5	+0·5	+0·5	+0·5	+1·0	+0·8	−0·3	0·0
October . .	−5·0	−6·0	−3·3	−4·3	−3·0	−4·8	−4·8	−5·5	−4·3	−4·8	−5·0
November .	−4·0	−2·5	−3·5	−2·5	−2·8	−2·5	0·0	0·0	−0·8	+1·3	+2·0
Autumn . .	−3·0	−2·7	−2·1	−2·1	−1·8	−2·3	−1·4	−1·5	−1·4	−1·3	−1·0
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September .	+2·6	+2·9	+3·0	+2·4	+2·0	+1·7	+1·9	+0·8	+0·2	+0·9	+1·1
October . .	+0·2	−0·2	+0·7	+0·3	+0·9	+0·4	+0·3	−0·7	+2·8	+1·3	+0·6
November .	−3·0	−2·4	−1·6	−1·5	−1·2	−2·1	−2·3	−2·7	−1·0	−1·9	−1·4
Autumn . .	−0·2	+0·3	+2·1	+1·2	+1·7	0·0	−0·1	−2·6	+2·0	+0·3	+0·3
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September .	−46	−17	−50	−62	−57	−71	−28	−47	−48	−36	− 5
October . .	+12	− 1	+ 2	+ 8	− 7	+ 8	+13	+12	− 4	− 4	− 2
November .	+11	+ 4	+ 8	+ 2	+ 3	+ 6	− 4	− 3	− 1	−17	− 5
Autumn . .	−23	−14	−40	−52	−61	−57	−19	−38	−53	−57	−12

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

and others. In many cases the leaves of the oaks, birches, and limes were riddled by them. *Penarth* (A)—Insects have been plentiful and various. Aphides have been exceedingly abundant on many plants. *Castleton* (A)—Seeds germinated with difficulty. *Bassaleg* (A)—27th. Wheat in ear. *St. Arvans* (A)—Much blight on roses and fruit trees. Oaks are being destroyed by caterpillars. 9th. Swift seen. Grass beginning to become burnt up. *St. Davids* (A)—Blackbirds and thrushes silent and scarce. *Killarney* (B)—A very floriferous spring in gardens, woods, and hedgerows. 1st. Corncrake heard. *Ferns* (B)—Runner beans cut away by frost. *Glendalough* (B)—Blossoms on all shrubs unusually abundant, particularly on the hawthorn, lilac, and laburnum. 30th. Potatoes and young bracken injured by frost. *Geashill* (B)—The blackthorn mingled its blossoms this spring with those of the hawthorn. *Bembridge* (C)—22nd. Dug potatoes and picked peas from the open ground. *Buckhorn Weston* (C)—30th. Meadow hay first cut. Wheat in ear. *Chislehurst* (C)—6th. First house-martin. 26th. First night-jar. *Churt Vicarage* (C)—Wasps very scarce. Much greenfly on roses. A plague of caterpillars on oak trees, quite half of which are stripped of their leaves and look like trees in winter. 1st. Potatoes seriously injured by frost. 11th. First May-fly. *Chiddingfold* (C)—Whole plantations of oak trees have been divested of every leaf, and present a curious winterly aspect. *Oxshott* (C)—By the end of the month the foliage of all the oaks in this district had been almost destroyed by caterpillars, the trees in many cases without a single green leaf. *East Molesey* (C)—Immense quantities of greenfly. *Marlborough* (C)—Blossom on hawthorn remarkably profuse, also apple blossom in gardens. *Cheltenham* (D)—Wonderful blossom on all trees and shrubs, notably on the blackthorn and hawthorn. Oaks and nut trees devastated by caterpillars. Many large trees stripped of their leaves. *Beckford* (D)—Much damage done by greenfly. *Watford* (D)—30th. Grass very much burnt up. *St. Albans* (*Worley Road*) (D)—10th. Swift first seen. *Evesham* (D)—1st. First house-martin. 4th. First swift. *Northampton* (D)—The show of hawthorn blossom was unusually fine. *Thurcaston* (D)—The dry weather has had a remarkable effect upon the flowering of different plants, some "come and go" with amazing rapidity, while others seem to hang on in bud for days, or even weeks. *Tean* (D)—Splendid show of hawthorn blossom this year. 8th. Swift seen. *Beeston* (D)—6th. Corncrake heard. *Macclesfield* (D)—Plums, apples, cherries, etc., simply covered with bloom. Horse-chestnuts, hawthorns, and laburnums were never more beautiful. Sycamores and oaks crowded with flowers. 21st. A sharp frost coming after rain killed French beans, dahlias, and strawberry bloom, while the fallen gooseberries almost covered the ground under each bush. *Hitchin* (E)—Flycatchers scarce this year. *Bocking* (E)—Fine show of blossom on most fruit trees and flowering shrubs. *Lexden* (E)—10th. First swift seen. 30th. Grass cutting began. *Palé* (F)—Crops on the level ground fairly good, very poor and dried up on the sloping ground, and burnt brown on gravelly soils. Extraordinary abundance of elder and hawthorn flowers. Wasps scarce. *Conway* (F)—Greenfly numerous on roses. Fine show of blossom on apple and cherry trees. *Cronkbourne* (F)—7th. A swarm of bees seen. *Piperstown* (G)—The bloom on the blackthorn and hawthorn has been wonderful. Wasps very scarce and late. *Westport* (G)—1st. Swift first seen. *Loughbrickland* (G)—The amount of bloom on the hawthorn is remarkable, the hedgerows have been everywhere one sheet of white. *Saintfield* (G)—10th. Swifts first seen. *Antrim* (G)—Such an array of hawthorn blossom has seldom been noticed. *Durham* (I)—Blossom on hawthorn phenomenal, horse-chestnuts also very fine. Small white butterflies numerous. 3rd. Corncrake heard. 18th. Swift first seen. *Corbridge-on-Tyne* (I)—Immense quantities of hawthorn blossom. Holly flowered very plentifully. The ash in leaf two or three weeks after the oak. *Lilliesleaf* (I)—Small white butterflies numerous. *Kirriemuir*

(J)—The blossom of the hawthorn, laburnum, and other flowering trees has been unusually rich. The hawthorn seldom flowers here before June. *Aberdeen* (J)—This is the first time that the hawthorn or horse-chestnut have been in flower here in May. *Inverbroom* (K)—7th. Corncrake first heard. 27th. House-martins first seen.

JUNE.—*Mawnan* (A)—8th. Annuals very slow in coming up, some not appearing at all. *Sidcot* (A)—Flowers generally, though early in coming out and profuse in quantity, are very soon over. *Bridgend* (A)—1st. Hay first cut. 10th. Much arable land is still lying quite fallow and overgrown with weeds. *St. Davids* (A)—Meadow-brown butterflies scarce. *Cork* (B)—Greenfly unusually abundant, especially on roses. *Killarney* (B)—Greenfly very numerous. *Geashill* (B)—There were but few wasps in the early part of the summer. Mushrooms abundant. *Bembridge* (C)—The exceptionally dry spring and early summer favoured the hatching and maturing of many insects destructive to fruit and plant life. Codlin moth very destructive to apple crop. Earwigs and woodlice infesting everything. *Westgate-on-Sea* (C)—Roses, fruit trees, and hops suffered greatly from greenfly till rain on 10th. 9th. Barley in ear. 10th. Oats in ear. 11th. Wheat in ear. *Chislehurst* (C)—21st. Nightingale last heard. *Churt Vicarage* (C)—Nightingales unusually numerous. *Churt* (C)—Nightingales more numerous than for past twelve years. *Chiddingfold* (C)—With the rain the leaf-rolling caterpillars dropped from the trees, and the oaks are recovering their foliage. *Winterfold* (C)—17th. The oaks are as bare as in winter, the caterpillars having eaten all the foliage on oaks, apples, and hazel. *Beckford* (D)—Engineers' drought of five consecutive months—January to May—with less than half the average fall. *Harpenden* (D)—3rd. First wheat ear out of sheath. *Harrogate* (D)—22nd. Hay harvest commenced. *Ambleside* (F)—By the beginning of the month, in some cases, the oaks had been nearly stripped of their leaves by caterpillars. Some oaks are loaded with oak galls ; indeed, some trees are quite red with them. *Orry's Dale* (F)—12th. Red Admiral butterfly first seen. *Newmill* (J)—6th. Strawberries ripe. *East Layton* (I)—Turnips generally had to be resown owing to drought and "fly."

JULY.—*Mawnan* (A)—6th. Ground strewed with tiny apples, also undeveloped plums. 11th. Wheat harvest began. 23rd. Wasps very plentiful. 25th. The first rain since March that has gone deeper than 1 in. into the ground. *St. Arvans* (A)—Butterflies numerous, especially tortoiseshells. *Killarney* (B)—Greenfly on hops beyond anything I ever saw—every leaf completely covered with them. *Buckhorn Weston* (C)—Harvest began generally on 13th, and nearly all stacked by 31st. 18th. Cuckoo last heard. *Westgate-on-Sea* (C)—Dry and hot till 14th, enabling early corn crops to be easily harvested. Much premature ripening of late sown barley and oats. *Chislehurst* (C)—Drought long, and trying to vegetation. 11th. The leaves on limes quite yellow, and some trees quite bare. *Coneyhurst* (C)—2nd. Cuckoo last heard. *Churt Vicarage* (C)—13th. Two ripe apricots picked from tree on S.E. wall of house. 27th. Harvest in full swing. *East Molesey* (C)—Grass quite brown ; vegetables very scarce. At end of month leaves turning yellow and falling off elms and limes ; some trees nearly bare already. 2nd. Oats cut. 23rd. Wheat cut. *Cheltenham* (D)—11th. Wheat harvest began. *Beckford* (D)—14th. Wheat harvest commenced. *Hodsock* (D)—During the last week of the month and the first fortnight of August hardly any flowers in the garden owing to thrips. 28th. Harvest began. *Bocking* (E)—17th. Harvest began—the earliest date since 1868. 31st. Ripe mulberries gathered. *Lexden* (E)—11th. Harvest began, oats cut. *Ambleside* (F)—12th. Buds and catkins formed on all forest trees for next year. *Newmill* (J)—16th. Cuckoo last heard.

AUGUST.—*Mawnan* (A)—18th. Apples still dropping badly from the trees. 27th. More rain has come, and everything is growing well at last and bursting into flower. *Bridgend* (A)—1st. Large quantities of mushrooms after the late rains. *St. Arvans* (A)—Grass lands generally scorched and bare. *St. Davids* (A)—Partridges plentiful and strong. *Killarney* (B)—Ivy flowered a fortnight earlier than its average date for the previous 14 years. *Bembridge* (C)—Wasps a great plague. *Westgate-on-Sea* (C)—Corn harvest finished by middle of month. *Cheltenham* (D)—The prolonged drought caused the trees in the town to lose their leaves fast, and even in the country the forest trees showed their autumnal tints. *Beckford* (D)—29th. The long drought at an end. Apples scarce and grub-eaten. *Hodsock* (D)—27th. Harvest finished. 29th. Two beech trees in one field turning brown, and some sycamore leaves falling. *Harrogate* (D)—3rd. Corn harvest began. *Bocking* (E)—1st. Pastures and lawns in the same parched and brown condition as at the beginning of June. *Palé* (F)—Great abundance of mushrooms. Wasps have increased to a troublesome degree. *Cronkbourne* (F)—Wasps very numerous. *Newmill* (J)—Scarcely any fruit on the forest trees except on planes, horse-chestnuts and limes, the rest are for the most part barren. Haws abundant. *Beauly* (K)—Grass plentiful all the summer. 10th. Harvest began.

SEPTEMBER.—*Mawnan* (A)—A wonderful year for sloes, haws, and blackberries. *Bridgend* (A)—An immense number of berries on the hawthorn this year. *St. Arvans* (A)—Berries very plentiful, especially haws. *St. Davids* (A)—Corn crops could not be got in owing to unsettled and stormy weather. *Glendalough* (B)—Wasps in unusual numbers during the late summer and early autumn months. Lime trees losing their leaves in the second week. *Bembridge* (C)—An enormous crop of mushrooms after the rain set in. *Cheltenham* (D)—The gales at the end of the month destroyed the remnants of the apple crop. *Berkhamsted* (D)—Nearly one-fourth of the apples in my garden have been blown from the trees by high winds. *Leominster* (D)—Large quantities of oak apples, whereas there were none in 1895. Heavy crops of acorns, nuts, beechmast, horse-chestnuts, hips, haws, and holly berries. 8th. Swift last seen. *Beeston* (D)—A great crop of walnuts and filberts. *Macclesfield* (D)—1st. Limes losing their leaves already. *Bocking* (E)—Haws remarkably plentiful. 1st. Pastures are producing mushrooms in great abundance. *Lexden* (E)—22nd. We have about ten or a dozen nests of martins round the house, some with young ones still in them. *Palé* (F)—Wild fruits, such as those of the crab, blackberry, hawthorn, holly, elder and mountain-ash, are very plentiful. Blackbirds, rats, and wasps quite a plague among fruit. *Piperstown* (G)—The haws and rose hips were wonderfully fine and plentiful. *Loughbrickland* (G)—Horse-chestnuts began to colour with the autumn tints in the middle of the month. *Jardington* (H)—Haws very plentiful.

OCTOBER.—*Castleton* (A)—Swallows unusually late in departing this year. *Aberystwith* (B)—1st. House-martin last seen. *Ferns* (B)—11th. Dahlias cut away by frost. *Churt Vicarage* (C)—15th. Much blight on main crop of potatoes. 20th. Dahlias killed. *Oxshott* (C)—Swallows seen regularly up to 10th, then none seen to 26th, and then none till November 5th. On October 26th and November 5th there were from 10 to 20 about. *Beckford* (D)—The leaves hung on the trees later than usual. 19th. Dahlias black with frost. *Watford* (D)—24th. Autumnal tints on beech trees much finer than in 1895. 28th. Dahlias killed. *Radlett* (D)—Great quantity of acorns. 9th. Fieldfares first seen. *Hodsock* (D)—The leaves, as a rule, have not turned much in colour, but have fallen off green. *Macclesfield* (D)—1st. Many limes and horse-chestnuts bare of foliage. *Ambleside* (F)—4th. Leaves falling rapidly, especially those of the lime and chestnut. *Aberdeen* (J)—2nd. Corn cut in August is still in the fields, and grain and straw considerably spoiled owing to wet, sunless weather. *Newmill* (J)—All the corn out during this month much damaged owing to almost incessant rain.

NOVEMBER.—*Marazion* (A)—The usual reappearance of house-martins took place early in the month, and for the first ten or twelve days the birds were fairly numerous. *Mawnan* (A)—28th. Nasturtiums still in flower. *Barnstaple* (A)—The number of individual autumn plants in flower was much smaller than in average years. *Bridgend* (A)—8th. All the leaves are off the trees except in the case of the oak and larch, the gales and frosts have cleared them off very quickly. *St. Arvans* (A)—8th. Trees are losing their leaves very fast now. Elms have not turned so golden as usual. *Ferns* (B)—27th. Some ripe strawberries gathered. *Glendalough* (B)—7th. Severe gale, which did much damage. *Muntham* (C)—6th. Last swallow seen. 7th. Found same bird dead. *Dover* (C)—Sudden change to colder weather on 27th, previous to which swallows were seen every morning near the water. *Chislehurst* (C)—3rd. House-martin last seen. *Churt* (C)—Holly berries most abundant. Spanish chestnuts very plentiful and good, acorns scarce. Fieldfares, redwings, and ouzels scarce this autumn. *St. Albans* (*Addiscombe Lodge*) (D)—30th. Gloire de Dijon rose still in flower. *Hodsock* (D)—The swallows remained very late this year. *Lexden* (E)—13th. Last martins seen. *Ambleside* (F)—Hollies thick with berries. *Ramelton* (G)—Hay still in cock in the fields. *Great Cotes* (I)—22nd. A house-martin was seen hawking round the house. *Durham* (I)—Snipes very plentiful, but woodcocks so far very scarce. *Newmill* (J)—Autumn tints poor.

DISCUSSION.

Dr. R. BARNES exhibited specimens of hazel and gorse gathered near Lingwood, Liss, Hants, the latter having been flowering all the winter.

Mr. F. C. BAYARD said that the Society was much indebted to Mr. Mawley, not only for the Report, but also the work he had done in this direction for previous years. He stated that in the *Transactions of the Croydon Microscopical Society* would be found a table by Mr. Miller on the early leafing of trees, and that on the previous evening a paper was read by Dr. Franklin Parsons on the early flowering of plants in the district round London.

Mr. H. SOUTHALL bore testimony to the value of the Phenological Reports. His own observations confirmed the accuracy of the deductions made by Mr. Mawley. With regard to the circumstance of the Marlborough observations, showing very early records of first flowering of the early plants, he thought it was probable that the boys of the college were more enthusiastic at this time of the year than the ordinary phenological observer. If a sunny day was neglected it was quite possible to miss the first flowering. The winter aconite in his garden first blossomed at the beginning of January, but the dull weather that had been since experienced had retarded any further flowering on its part. He thought the hawthorn and the blackthorn two of the best plants possible for the purpose of comparison. He had not missed the first flowering of either for many seasons. From his observations the range of the hawthorn was about six weeks, from April 15 at the earliest to the end of May at the latest. The last five years were the earliest seasons he remembered, excepting perhaps the years 1846 and 1868.

Mr. R. INWARDS inquired if any observations had been made of the greatest depth to which the wheat sends down its root. It was no uncommon thing in Wiltshire for the wheat roots to penetrate the chalk soil to a depth of 6 feet, and he thought even 9 feet, in particularly dry seasons. It would be interesting to have records of these facts.

The President (Mr. E. MAWLEY), in reply, said that he did not consider that the specimens of hazel and gorse shown by Dr. Barnes were exceptional, as there were no fertile flowers to be seen on the former; and it was seldom that a flowering sprig of gorse could not be gathered at any season of the year. He had recently received a letter from one of the original founders of the Society, the Rev. J. Slatter, Vicar of Whitchurch, in Oxfordshire, who stated that last year the catkins on the nut trees in his garden were in flower about the middle of January; but that the fertile flowers did not make their appearance until the middle of March, when the catkins had nearly disappeared. Mr. Mawley said that he was always glad to receive any long records of the first flowering of plants, or of the first appearances of birds or insects, as they were of great value in checking the returns sent in from the Society's observing stations in the districts where such records had been kept. Only last year Mr. A. W. Preston of Norwich, one of the Fellows and a phenological observer, had sent him a record of this character, which had been kept by the Marsham family at Stratton, in Norfolk, for altogether more than 100 years. Unfortunately, only two of the plants mentioned in it were the same as those in the Society's list. On the other hand, it was very gratifying to find that the mean date given for the most important of these, the hawthorn, differed by only one day from that obtained for the past six years' observations at the Society's stations in the east of England. With regard to what Mr. Southall had said as to the erratic flowering of the winter aconite this year, he might state that in his own garden at Berkhamsted the blossoms were erect and ready to open with the first gleam of sunshine on January 6, but the stamens were not visible until February 7, owing to gloomy weather in the first instance, and afterwards to the plants being covered by snow when at last the sun did shine. So that instead of obtaining the earliest date for the opening of this flower he had yet recorded, the actual date was among the latest. Mr. Inwards' remarks respecting the deep rooting of wheat served to explain why this cereal had suffered so slightly during the trying drought of the past year.

RESULTS OF OBSERVATIONS ON HAZE AND TRANSPARENCY NEAR HASLEMERE, SURREY.

By the Hon. F. A. ROLLO RUSSELL, M.A., F.R.Met.Soc.

[Read February 17, 1897.]

The observations, of which a brief summary is given below, were mostly made at a point situated a mile and a half from the summit of Hindhead, 40 miles south-west of London, and 630 feet above the level of the sea. The directions in which the transparency or opacity was noted were generally south-west, south, and south-east to east. The total number of days on which the weather was described in 1895 was 332, but, on a considerable number of those days, the required data of atmospheric transparency were not obtained, owing to fog, mist, cloud, rain, snow, or other reasons. The total number of days brought into account for distances was 183.

The distances of visibility were roughly set down according to the distance of visible landmarks, and especially of certain hills at 2, 5, 10, 13, and about 22 and 40 miles. If a hill at 22 miles were perfectly definite in outline, it would be assumed that another at 40 or 50 miles would be visible, and in the case of long distances a figure was always taken less than the probable distance to which vision would extend. The visibility generally refers distinctly to the upper portions of hills between 400 and 900 feet in altitude, and these being viewed from a height of 630 feet, it is obvious that sometimes a high transparency would be noted while the lower ground remained under a covering of fog, and that sometimes, on the other hand, a low transparency would be noted when the clouds hung on the hills and the lower country was fairly clear.

In January only a few observations of distances were taken, and none were taken on the following days:—April 1 to 16, 21 to 24; September 11 to 16; November 20; December 2 to 4, 9, 10, 14 to 16. From July 7 to 27 the notes refer to Sandown, Isle of Wight.

The hours of observation could not unfortunately be always the same, but 8, 9, 10 a.m., noon, and 2 p.m., were the most usual. In making out tables in relation to the winds from the eight points of the compass, I have usually, unless reason appeared for another course, inserted in the column representing the hour between two hours when observations were made, an intermediate figure, or a figure agreeing with the normal rate either of increase or decrease. For example, on February 19 the distances were at 8 a.m. 5 miles; at 10 a.m. 10 miles; at 11 a.m. 9 miles; at 4 p.m. 10 miles; to 9 a.m. 7 miles, and to the hours of 12 and 2 p.m. 9 and 10 miles are respectively assigned. Any abnormal increase or decrease would almost certainly have been noted.

In every case where the direction of the wind was not from one of the eight points, that to which it was nearest was set down.

I am well aware that these notes leave much to be desired, but believe the results approximately represent the main facts.

TABLE I.—DISTANCE OF VIEW IN MILES FOR EACH WIND AT THE HOUR STATED.

Direction of Wind.	8 a.m.	9	10	11	Noon.	1 p.m.	2	3	4	Mean.
N	11·4	12·5	13·0	14·0	13·1	...	12·9	...	(14·6)	13·0
NE	9·8	9·5	9·0	9·8	10·0	10·2	10·4	10·1	10·0	9·9
E	9·75	11·2	12·6	13·8	14·7	...	13·9	...	13·9	12·8
SE	10·6	12·0	13·1	14·5	16·1	...	17·0	...	17·0	14·3
S	20·4	21·3	22·9	24·4	24·3	...	25·0	...	26·3	23·2
SW	24·2	25·1	24·6	25·4	25·0	...	25·4	...	27·9	25·4
W	25·6	27·1	29·0	29·4	29·9	...	29·9	...	29·3	28·6
NW	22·9	23·7	24·4	24·0	23·3	...	22·7	...	21 (?)	23·1
Calm or light variable airs, excluding foggy days	14·3	14·6	15·3	15·8	16·5	...	17·0	...	18·3	15·9

From Table I. it appears that the West is the clearest wind, after which follow in succession South-west, South, North-west, calm, South-east, North, East, and lastly North-east. The North-east wind is about three times as opaque as the West, and the East twice as opaque as the South-west. The South-east is probably somewhat clearer than appears from the table, for only 7 days of this wind afforded data, and a period of dry summer weather during its prevalence would soon raise the average. All the winds, except the North-east, increase in clearness up to 11 a.m., the East and South-east by 4 miles, and the North by 2½ miles. The maximum hazing with the North-east wind is at 10 a.m. The clearness of the North-west wind diminishes during the afternoon. At 8 a.m., an hour at which the effect of smoke from distant places may be left out of account, the order of clearness is as follows:—West, South-west, North-west, South, calm, North, South-east, North-east, East. It is probable that here the South-east should precede the North.

The following were the results for North-east winds in the four quarters of the year:—

TABLE II.

Quarters of Year.	8 a.m.	9	10	11	Noon.	2 p.m.	4	Number of Days NE Wind.
1st .	7·7	7·3	7·3	(7·7)	8·1	9·3	8·5	19
2nd .	12·4	11·7	10	9·9	12·3	11·8	11·2	10
3rd .	7·9	8·4	9	9·2	10·4	10·8	11	5
4th .	11·4	10·5	10	10·4	9·5	9·7	9·4	6

In each quarter except the third, in which there were no strong winds,[1] a decline of transparency occurred towards the middle of the day.

The distances for strong winds were as follows:—

	8 a.m.	10 a.m.	Noon.
Strong NE (17 days)	8·9	7·5	9·2
,, E (6 days) . . .	10·5	15·5	19·5
,, N (6 days)	16	16·8	15
,, NW (6 days)	23·7	25·6	25
,, W (11 days)	29	31·3	32·4

On many days when the wind on Hindhead was North-east, or was noted as North-east, it did not blow exactly from that direction at the

TABLE III.

1895.	8 a.m.	10 a.m.	Noon.	Remarks.
Jan. 10 . . .	10·0	5·0	3·0	Estimated velocity about 13 miles an hour at 8 a.m. Smoke arrived 9.45.
Feb. 3 . . .	3·0	3·0	3·0	
,, 4 . . .	6·0	9·0	13·0	Wind veered to East in London; hence smoke did not pass over Hindhead.
,, 5 . . .	5·0	5·0	(5·0)	Wind moderate at 8 a.m.
,, 20 . . .	3·0	0·75	4·0	Wind estimated at 20 miles an hour at 8 a.m. Smoke arrived at 9 a.m.
,, 25 . . .	7·0	9·0	13·0	Strong. Smoke arrived at 8.45 a.m., and reduced visibility to 4 miles. Wind slightly shifty.
March 12 . . .	1·0	0·75	3·0	Fresh. View 1½ miles at 8.50 a.m. Smoke arrived at 10.
May 4 . . .	7·0	9·0	18·5	Fresh. View 7 miles at 8 a.m.
,, 6 . . .	13·0	2·5	(8)·0	Fresh. Smoke arrived at 9.25 a.m.
June 7 . . .	13·0	6·0	9·0	Strong. Smoke arrived at 8.40 a.m., and reduced the view to 6 miles at 9.15.
Nov. 24 . . .	16·0	9·0	7·0	Strong to very strong. Smoke arrived about 8.45 a.m., reducing view to 9 miles at 9 a.m., and 8 miles at 9.30.
Dec. 25 . . .	8·0	5·0	6·0	Fresh. Smoke arrived about 9.30 a.m.
Mean distance of view	8·1	5·4	8·1	

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[1] With the exception of July 5, counted into the second quarter, owing to the removal from Haslemere on this day.

nearest station in S.E. England, and was read as East-north-east or North-north-east; on other days while the wind at this level was gentle or even moderate from North-east, a different current or calm prevailed on the low ground. On the days mentioned below, wind was strong or fresh from North-east on Hindhead, and North-east also in London either at 8 a.m. or 2 p.m., or both. Table III. gives the distance of view at Hindhead on these days at 8 a.m., 10 a.m., and noon.

In this result the effect of London smoke brought down to the extreme south-west corner of Surrey within three hours of the lighting of fires is very plain. Previous years gave similar examples, of some of which I have record. I have always found that the smoke produced during the first hour of fuel-consumption greatly exceeds in amount and obscuring effect the smoke evolved during the daytime, when many fires are burning without perceptible smoke. On May 4, when the transparency exceptionally increased from 7 miles at 8 a.m. to 18·5 miles at noon, the view eastwards extended to 23 miles, and westwards only to 14 miles; the figure for noon is given as a mean value. The wind on this occasion was probably a little East of North-east.

On the following days wind was gentle from about North-east on Hindhead. In London the direction of the wind frequently differed somewhat from that on Hindhead, and sometimes blew from an opposite quarter, or there was calm at 8 a.m., succeeded by a gentle breeze. Observations at 630 feet altitude give a truer indication of the main lower current than those at lower stations. The figures represent distances in miles.

TABLE IV.

1895.	A.M.		Noon.	P.M.		REMARKS.
	8	10		2	4	
Jan. 30	7	2	3	3	3	Calm to ENE in London.
Feb. 8	6	8	10	10	10	E to NE ,,
,, 9	2·5	6	7	8	10	WSW to calm ,,
,, 10	10	10	10	10	10	ESE ,,
,, 13	3	5	7	7	7	W to calm ,,
,, 17	6	8	10	20	2·5	Calm at 8 a.m. ,, NE at 2 p.m. at Dungeness, and probably London.
,, 19	5	10	9	10	10	ENE in London.
April 28	10	10	9	5	5	NNE ,,
May 5	27	15	12	18	20	NNE ,,
,, 21	7	14	14	14	3·5	Calm to very light NNE in London.
June 3	15	16	14	10	9	SW to NE in London.
July 5	2	5	4·5	4	5	NE ,,
,, 31	2	3	4	5	6	NE to NNE ,,
Sept. 8	4	5	7	7	7	E ,,
,, 23	13	13	14	14	14	Calm to ESE ,,
Oct. 18	23	20	20	20	20	NE to ESE ,, (light).
Dec. 19	7	7	7	3	4	ENE ,,
Mean	8·8	9·2	9·4	9·8	8·6	

It will be observed from Table IV. that on the two occasions when a heavy fall in clearness occurred during the afternoon, there had been calm in London, succeeded by a North-east breeze. The accumulated smoke mass drifting over the country produced dense haze.

In the cases of gentle wind above tabulated, it appears that the transparency of the air generally increases slightly towards the middle of the day. But if the views northwards as well as southwards had been taken into account, a diminution of view would probably have been shown during the early afternoon. On February 8, for instance, though the weather was very bright at Haslemere, a thick smoky haze extended from Godalming to Woking between 11.40 a.m. and 0.20 p.m., and probably later. Similarly on February 13 a dense yellow pall of smoke extended from Milford to 2 miles north of Guildford about 1.30 p.m. There was also a dense yellow haze between Walton and London. On this day, at 11.40 a.m., rounded clouds of smoke had passed at a high elevation above the neighbourhood of Haslemere, showing the foggy calm in London in the morning to have above it a breeze from about North-east, as at Haslemere. On February 17 the view diminished from 27 miles at 0.40 p.m. to 1 mile at 4.30 p.m. owing to the accumulated masses of smoke brought down by the breeze after calm. Many similar instances could be given, and of a great rise or fall of transparency eastwards or westwards owing to a shift from, or to, North-east.

On many occasions, however, a great increase of fog or haze occurred about 9 or 10 a.m., or even 11 a.m., in winter, without any possibility of London smoke being the cause. This haze or fog, spoiling some of the most brilliant mornings, was ascertained to be the stratus or haze which had lain over the low ground at night, and in the morning was raised by the warming effect of the sun's rays. The phenomenon took place only on calm mornings, or with a gentle or moderate breeze, by no means always from the North-east, as in the case of smoky obscuration. On mountains of the height of Ben Nevis or Snowdon the dusty air from the plains has been observed to reach the summits about mid-day. Heights of 600 to 900 feet appear therefore to be affected several hours earlier.

High Visibility.—On 57 days the views were visible to a distance estimated between 22 and 49 miles. Of these 57 days 40 were fine; 17 with some rain; 27 with fresh or strong wind; the following 24 hours were fine in 35 cases, with rain in 21 cases. 16 of the 57 days were in the first six months of the year, 41 in the last. The following figures give the number of days with the different winds:—

N	3	SE	2	W	12
NE	3	S	5	NW	5
E.	3	SW	20	Calm	4

S.W., W., and N.W.:—37 out of a total number of 67 days of Westerly wind.
N.E., E., and S.E.:— 8 ,, ,, 65 ,, Easterly wind.
On 27 days the wind was fresh or strong on Hindhead.
On 11 days the force in London at 8 a.m. was 4 or more.
On 34 days ,, ,, 2 or 1.
On 14 days the day was described as cool or cold.

The average difference between the readings of the dry and wet bulb thermometers in London at 8 a.m. was 3°·7 on 52 days.

Besides the above 57 days, there were 18 days when the transparency exceeded 50 miles. Of these 18 days, the wind was:—

N	0	SE	2	W	7
NE	1	S	1	NW	1
E	0	SW	5	Calm	1

On 7 occasions the wind was veering somewhat towards West or North.

On 12 ,, the weather was fine, but in 5 of these cases rain or snow had fallen in the night or early morning.

On 4 occasions there were heavy showers; on one the visibility (50 miles at 6 a.m.) was followed by continuous rain.

On 7 occasions the weather was noted as cool or colder.

On 8 ,, the following 24 hours were fair.

On 10 ,, ,, ,, rainy or showery.

The sum of the differences of dry and wet bulb thermometers in London at 2 p.m. (or at Dungeness on Sundays) on the days of greatest visibility (omitting August 4) was 99°. On 17 hazy days taken as near as might be to the days of transparency, the sum of the differences was 90°. Some of these days may have been characterised by mist or thin fog. Thus no appreciable difference in dryness between these days is apparent, and the view expressed in a previous paper that the main cause of difference between transparency and haziness, in this climate, is not simply humidity, receives strong corroboration.

The season of greatest clearness corresponds with that during which the upper and lower currents are most similar, and the mean temperatures of sea and land most in agreement. The great majority of cases of visibility is with winds between South-west and North-west, and these winds must be in closer agreement with the temperature of the sea over which they have blown than any other winds, for they have passed over a greater extent of ocean of nearly uniform temperature.

TABLE V.—TOTAL RESULTS OF VISIBILITY ABOVE 22 MILES.

VISIBILITY.	Weather.			Following 24 Hours.		Wind between	
	Fine.	Some rain.	Fresh or strong wind.	Fair.	Rain,¶ more or less.	SW and NW	NE and SE
22 miles to 50 miles (57 cases)	40	17	27	35	21	37	8
50 miles and over (18 cases)	12	6	4	8	10	13	2
Total (75 cases)	52	23	31	43	31	50	10

Among Westerly winds, the percentage of Westerly winds (S.W. to N.W.) with views over 22 miles during at least a part of the day was . . . . . . 49·5

Among Easterly winds (N.E. to S.E.) the percentage was . . . . 13·2

,, N winds the percentage was 15

,, NE ,, ,, ,, ... 10

,, E ,, ,, ,, ... 15

,, SE ,, ,, ,, ... 25

,, S ,, ,, ,, ... 48

,, SW ,, ,, ,, ... 53·2

,, W ,, ,, ,, ... 54·3

,, NW ,, ,, ,, ... 31·6

Calm or variable ,, ,, ,, ... 31·2

These percentages are obtained from the whole number of available observations in 1895.

The order in which the winds afford instances of great visibility is as follows:—West, South-west, South, North-west, calm, South-east, East and North, North-east, which is somewhat like with the order according to average distances in miles given on p. 146. The agreement is, indeed, surprisingly close.

The cases of visibility above 22 miles at 8 a.m., noon, and 2 p.m., were as follows:—

	8 a.m.	Noon.	2 p.m.
N . .	4	2	2
NE . .	3	0	0
E . .	0	2	1
SE . .	1	1	1
Total .	8	5	4

	8 a.m.	Noon.	2 p.m.
S . .	3	5	7
SW . .	12	16	17
W . .	12	18	19
NW . .	7	6	4
Total .	34	45	47

Thus it appears that for every case of visibility above 22 miles at 2 p.m. with wind between North-north-west and South-south-east on the Easterly side, there are 11 cases with wind between North-north-west and South-south-east on the Westerly side.

The clearest months are July, August, and September; the haziest are December, January, and February.

The early hours of the morning are, in general, hazy or misty, even at the elevation of 600 feet, and a visibility of about 6 miles is usual before 7 a.m. Occasionally, however, the early hours are remarkably clear, especially, perhaps, when the air is very moist, with heavy dew, or mist on the low ground. With all winds, except North, North-east, and North-west, the air becomes continuously clearer till 2 p.m. In the case of the North-east, London is the certain cause of the increased haze from 8.40 to 11 a.m. with strong winds, and from 12 to 3 p.m., or 2 to 4 p.m., on some days with gentle breezes; in the case of the North-north-west, counted as North, the afternoon hazing may sometimes be due to smoke from the manufacturing towns in the Midlands.

Of a total of 31 cases in which visibility quickly diminished and hazing occurred during the day, 12 cases were with a veering, 4 with a backing wind, 11 with contending winds or obviously mixing currents, not included in veerings and backings, 1 with wind varying between North and North-north-west, 2 or 3 at least with clouds covering the sky or increasing. On April 1 the frosty air from the land blowing from East or East-north-east over the Solent produced a mist amounting to fog within 30 feet of the surface of the sea, and although the sun was shining brightly on the masts of ships, the regular steamboats did not attempt to cross to the Isle of Wight.

Of a total of 13 cases of clearing or increase of visibility, 8 were with a veering, 1 with a backing wind, which at the time was increasing in force, 1 was with a steady South-west, 1 with West-south-west replacing calm, 1 with South-east turning calm, and 1 with North-north-east wind extending to a height, where a few hours before the wind had been South-west.

Out of 15 cases of hazing with veering or backing winds, in 6 cases the change of wind was sudden, in 4 rapid, in 2 moderate, and in 3 slow.

Out of 10 cases of clearing with veering or backing winds, the change of wind was sudden in 1 case, rapid in 2 cases, moderate in 2, rather slow in 1, and slow in 4.

For certain purposes the following conclusions may, I think, be accepted at least for the district referred to, and probably will apply to a great part of this country:—

The most favourable season for army signalling from hill to hill, for photographing distant views and clouds, and for some astronomical purposes, is the summer and early autumn. The clearest hours at a good distance from towns are about the middle of the day, say noon to 3 p.m. The clearest winds are those from South to North-west inclusive, and especially West-south-west, West, and West-north-west; the haziest are those between North and East. On bright mornings with a gentle breeze or calm, from autumn to spring, the haze or fog which has lain on the low ground frequently covers the hills in the course of its ascent a few hours after sunrise. At any distance within 100 miles of London, or of the Black Country, observations requiring clear views are likely to be interfered with when the wind blows from those localities, and should therefore be taken early.

DISCUSSION.

Mr. R. Inwards gathered from the paper that visibility seemed most prevalent with those winds which crossed the largest expanses of water. He did not know if it was the practice of observers on the coast to make observations both to seaward and landward. Perhaps Mr. Scott could give them the information. If not, he thought a comparison of this kind would be interesting.

Mr. F. C. Bayard inquired at what distance town smoke could be seen, and whether it was possible that visibility could be affected by the smoke of a town 40 miles off. He should also like to know the extreme distance that London smoke could influence the atmosphere of the surrounding country.

Mr. R. H. Scott, in answer to Mr. Inwards, said he did not know of any places on our coasts where observations of visibility were made both to seaward and landward. The Kew experiments were still being carried out. Mortlake Church, distant about 3 miles, and intermediate prominent points, such, for instance, as the Pagoda in Kew Gardens, were used in noting the various degrees of obscuration. But this is found to be greatly affected by the angles at which the light falls on the different objects. Some very interesting observations had been made by Mr. Cruikshank at Aberdeen, and were printed in the *Journal of the Scottish Meteorological Society*. A paper by Dr. Schultheiss had also appeared in the *Meteorologische Zeitschrift* for December 1896 on this subject. An observer for the Baden weather system, in the Black Forest, always took note when the Alpine chain was visible. The station was at an altitude of about 3000 to 4000 feet, and the lowest portion of the chain about 7000 feet. The Alps were more frequently visible in winter than in summer, and the visibility often lasted for a number of days; in fact, once on fifteen consecutive days a magnificent panorama was visible. It was most frequently accompanied with anticyclonic conditions, and a descending current over the Alps. It was completely independent of town smoke, and the results certainly disagreed with the general idea in weather prognostics that visibility is usually followed by rain.

Mr. F. Druce said that he had made observations, under conditions very similar to those of Mr. Russell, for the past three or four years, and the conclusion he had come to was that winds from the South-east were proportionately clearer than those from any other quarter. He noticed in the paper that no observations were made later than 4 p.m. His own results showed 6 p.m. to be also very clear. It would be interesting to compare observations from a station the same distance to the north-east of London that Haslemere was to the south-west. Perhaps some idea of the effect of smoke could be arrived at in this way, making due allowance for the relative frequency of North-east and South-west winds.

Capt. A. S. **Thomson** thought that the hygrometrical condition of the air had scarcely been considered sufficiently in the compilation of the paper.

Capt. A. **Carpenter** said that undoubtedly drifting smoke was a difficult matter to contend against in making observations on haze due to meteorological conditions. He remembered that during a blizzard in the winter of 1891-2, when he was staying at Wexford, in Ireland, the snowfall was heavily charged with soot. The wind was from East by South, in which direction there was open sea as far as the Welsh coast, 90 miles distant. After the snow melted the soot lay about the ground in black lines.

Mr. G. J. **Symons** remarked that though he could not say the extreme distance to which London smoke was carried, yet it was certainly held responsible for the discoloration of a fall of snow occurring as far away as Reading. On a section being cut through the snow, a distinct black layer was seen.

Mr. H. **Southall** thought that the influence of both London and the Black Country on the atmosphere of the surrounding districts was visible and provable. Where he resided, at Ross, in Herefordshire, Easterly and North-easterly winds were invariably much thicker than those from West or South-west. This was the same as found by Mr. Russell, though he (Mr. Southall) did not think Ross was influenced either by London or the Black Country.

Mr. F. J. **Brodie** said that the question as to the possibility of London fog reaching as far as Haslemere seemed to him to be solved by the facts given in the paper, which showed that the North-easterly wind was by far the most hazy. He could not see why the wind from any specific direction should bring murky weather, unless it had, in the course of its passage, been infected by the impurities arising from large cities or from important manufacturing centres. He fully agreed with Mr. Druce's suggestion as to the importance of a comparison between Mr. Russell's observations and those made at a station lying at an equal distance to the north-eastward of the metropolis.

Mr. F. **Gaster** inquired whether the wind observations made on Hindhead were local or general currents; as there were frequently local currents on hilly districts, which were liable to mislead one as to the general conditions prevailing. He thought the conclusions arrived at in the present paper differed to a large extent from the views put forward by Mr. Russell in his former paper.

Mr. W. **Marriott** thought that if Mr. Russell had made a collation of observations of the different types of weather prevailing at the times of visibility or obscuration it would have assisted him considerably. He (Mr. Marriott) had taken several cases cited by Mr. Russell, and had referred to the *Daily Weather Reports* for those days, and had found that, in almost each case, there had been anticyclonic conditions prevailing, the descending current preventing the smoke from ascending. He had frequently noticed in Norwood that gloomy and hazy weather occurred with a Northerly wind.

The Hon. F. A. R. **Russell** said, in reply, that one of the most remarkable results of these observations, and most surprising to himself, was the regular mean increase of haze towards a maximum with wind from North-east, and the regular mean decrease towards a minimum with wind from West. That is to say, the mean amount of haze with any wind is related to its position with regard to each of these points of maximum and minimum. As to the identification of

London smoke at 40 miles' distance, which Mr. Bayard doubted, he could say for certain that the appearances noted were due to this cause, and had many times verified the expected arrival of smoke at an hour depending on the strength of the wind. He did not wish to imply that at this distance London smoke interfered with the view very frequently, but on the most favourable days the transparency of the air was greatly diminished for a few hours. The differences between Table I. and the percentages following Table V. were accounted for by the latter including many days on which the distances were not noted, and on which, in taking percentages, it is assumed that the visibility did not reach 22 miles. The observations of Dr. Schultheiss mentioned by Mr. Scott were very interesting, and, on consideration, the transparency above 6000 feet with anticyclonic conditions was what might be expected, the upper air being dry, and even traces of the smoke and dust of the lower strata not reaching these heights till the evening. With regard to Mr. Gaster's remarks, he intended the present paper to be supplementary to that recently read, and by no means contradictory to it. He had no doubt that the mixture of differing currents or laminæ was the main cause of haze in this climate, but this did not exclude the effect of smoke borne by the wind.

THE WINTER CLIMATE OF EGYPT.

By H. E. LEIGH CANNEY, M.D., F.R.Met.Soc.

[Read December 16, 1896.]

Up to the present time such observations as have been made on the climate of Egypt, as far as they have been consecutively taken, have been generally limited to Alexandria and Cairo. No definite knowledge has been obtained of the conditions present in the Nile valley. As regards the desert, from the nature of its inhospitable surroundings, our sources of information are limited to the notes and observations of various scientific expeditions that have traversed the Sahara to and from the Nile valley, and these, being taken in transit, naturally are not continuous for any spot for any long period. Observations at Luxor or some other point in the Nile valley, south of Cairo, have been taken by men residing for a short time, such as those by Mr. Maclean, M.B., B.S., at Luxor in 1868,—very excellent in themselves, yet not arranged to be synchronous and comparable with observations at other stations, and, therefore, of limited value. The remaining observations available are those of travellers on the Nile itself, generally in dahabeahs and under constantly varying conditions.

The present series of observations was undertaken three years ago, with the kind assistance of several friends at other stations in Egypt, provided with similar instruments, and working on the same method at comparable sites, in order to arrive at a knowledge of the climate of Egypt generally, and of the Nile valley specially, during the winter. Such information was specially needed by those of us resident as physicians in the country, and by the medical profession generally. In this paper, however, the medical aspects of the climate, interesting though they would be, will not be discussed.

General Climatic Conditions.

Although this paper will be limited to the winter conditions chiefly, reference will occasionally be made to the conditions present at other times of the year. Egypt, like other countries, depends for its climate upon its surroundings; the geographical, geological, and topographical conditions of these surroundings will largely influence such factors of its climate as the temperature, humidity, and the presence of air-borne particles, organic or inorganic. The consideration of the surroundings is especially important, in the case of Egypt, if we are to attempt to understand its climate.

Egypt, as we shall consider it in this paper, is nothing else but that portion of the Sahara, only eight or ten miles broad for nine-tenths of its length, which the Nile has been able to cover for countless years with its annual deposit of mud from Abyssinia and Equatoria, and through which it still flows, the only river of the Sahara capable of resisting the sun's power. We look on Egypt as that narrow road across the Sahara desert to the Soudan, where one's caravan could constantly obtain water and, for the most part, pasturage. To take a similar direction only a few miles east or west would be to travel through frightful solitudes, through deserts of fascinating loneliness, of boundless wastes of rising and falling ground; here, low rounded disintegrating sandstone hills, with overhanging edges on one side, and in the gorge between this and the next the drift-sand, which, driven by the wind for countless ages, has helped the sun in the process of disintegration; there, long stretches of undulating plains of limestone scattered with broken portions split off by the enormous variations of heat and cold; here again, the long succession of sand-dunes stretching away for hundreds of miles, often rising to the height of 300 feet, and curiously found to have been heaped up, grain by grain, by the prevailing winds, thus forming a gigantic indicator and record of their direction, and resembling a golden sea struck suddenly silent and still. Above is the deepest blue, cloudless firmament, the sun rising and setting like a brazen mass in a violet sky, the air invigorating and fresh as it is hot, yet with no trace of human or other life, vegetable, animal, or even germ. Day after day to cease to advance day or night, for hundreds upon hundreds of miles, is death, in a climate unequalled elsewhere; yet at what a cost has this been effected.

The Punjab, Mesopotamia, and other countries are hotter in the summer than the centre of the Libyan desert, and they flourish under an equally powerful sun. The soil of the Sahara only needs occasional rain and the desert would spring into verdure instantly, but its climate can give it little or no moisture, as it often affords only the softly shimmering miraged lake with its feathery palms.

Neither the sun nor the soil is the cause of the desert, but the climate alone. Standing on either bank on the cliffs that overhang the Nile valley and form the escarpment of the Sahara plateau, which, for the most part, is over 500 feet higher than the mean of all Europe,[1] we look out on the desert, the gift of the climate, and below us we see Egypt, the gift of the Nile.

[1] M. Chavanne, *Afrika im Lichte unsrer Tage.* Vienna, 1881.

In a country where the possible evaporation far surpasses the rainfall, there must be progressive dryness going on. Such rivers as did exist in the Sahara run only a short distance now, or appear as a string of shallow lagoons, united from time to time by a small stream; the Nile alone reaches the other side. Lakes once filled with fresh water, now by successive evaporations, are reduced to brine, their edges sparkling with salt ridges, like foam.[1] In parts of the Sahara, as in Tunis, masses of brine and sand have rendered a crust possible over a syrupy lagoon, where a caravan can disappear, camels and all, and leave no trace.[2]

Winds have been called "the vehicles of the climate," and we shall see later the large influence the winds of the Libyan desert have over the climate of Egypt; we must, however, first refer to the probable causes of the direction taken by these winds:—

(1) The *barometric pressure*. This Hann has pointed out increases during winter from the sea towards the interior, at least as far as Cairo and Assiout, and probably into the Libyan desert.

(2) The *lower temperature of the Libyan desert in winter*. At the great sand-dunes (lat. 25°) the temperature was 7° colder than at Cairo[3]; at Farafrah (lat. 27° 2′), 5°-9°; at Dakhel (lat. 25° 42′), opposite Luxor, 2°; which, with the difference between Cairo and Alexandria, gives a difference of about 6° between the desert and the Mediterranean. These facts point to the presence of a region of high pressure in the north of the Libyan desert and south of Tripoli, as Hann has pointed out, and characterised by calms and variable winds, as at Mourzouk. From the neighbourhood of this area the winds of winter escape as a South-west wind to the north, North-west to the east, North-east to the south, and South-east to the west. Thus at Alexandria the South-west wind predominates, at Cairo South-west and North-west equally; in Tripoli, West and South-west; in the south of Libyan desert, Upper Egypt and Nubia, North-west. In the central desert and Upper Egypt there is a large proportion of calms. In summer, as has been shown by M. Schirmer, from the records of Rohlfs, Duveyrier, Nachtigal, and Cailliaud, the reverse takes place, the Sahara is hotter than the sea, the pressure is lower towards the Sahara centre than the sea, and the area extends farther south than that of the winter. The continent draws in the winds on three sides to the centre, the Etesian winds of Herodotus in the north, the South-west rainy winds in the West Soudan, and the South-east winds on the Upper Nile.

Libyan Climate.

Having referred generally to the winds which bring Egypt its climate, we shall now glance at the characteristics of this Libyan climate. First, the humidity, for, in proportion to its amount, considered relatively, so will be the vast natural effects produced. As is well known, the reduction of a few inches in the rainfall annually will produce a *steppe*, and a further reduction a desert; so between the Soudan and Sahara is a tract of country with limits varying from year to year, presenting these changes. From the south of the Sahara one passes from the desert, absolutely sterile, through islands of *mimosa*, dotted in seas of sand, into the verdant Soudan, and thence into the virgin forests of equatorial Africa. A year or two later, the intervening country may be a desert, the northern limit of the South-west rainy winds in summer having been pushed one way or the other with equally favourable or disastrous results. In the centre of the Libyan desert in winter, the air is found to be dry, and it remains so owing to the movement of descent compensating the escape of air in all directions from the centre. This colder upper air, not sufficiently moist to cause rain, now descends and passes from this Libyan desert centre towards the centres of lower barometric pressure, and in doing so is heated by the desert surface, and rendered drier still. A shower condensed in the upper regions over the desert has often been seen to be dissipated before reaching the earth, but at Luxor on March 15, 1895, during a strong South-west Khamseen wind, drops of rain were felt, when the relative humidity was only 40 per cent. On another occasion at 6 p.m., under similar conditions, spots of rain were falling, though the dry and wet bulb thermometers showed a difference of 20°. In summer the winds are reversed, coming into the Sahara from the sea on all sides, so that even at the centre there is found to be a large quantity of vapour, even more than could be contained in the air of London at any time. The advance being on all sides, the relatively drier North wind from the Mediterranean prevents the advance of the rainy South-west wind, and thus limits the encroachment of the Soudan on the desert; were it not for the Mediterranean conditions would change. The relative humidity may be extremely low, as Rohlfs found in April 1880, for five days, from 10 a.m. to 4 p.m., 3 to 8 per cent only, in the valley of Ighargharen. The mean relative humidity of the Libyan desert in winter is 50 per cent (Jordan 1873-74); at Djofra, 41 per cent, in February 1879 (Rohlfs); of Biskra, 62 per cent from December to February (for ten years, 1879-89). The mean of the Sahara is about 46 per cent in winter (Schirmer).

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[1] Rohlfs, *Kufra*. [2] *Journal Asiatique*, 1852. Voyage dans la Régence de Tunis.
[3] Rohlfs, 1873-74. [4] Sahara. Paris, 1893.

The moisture remains invisible generally, the cloudless sky being of a remarkably deep blue, or even indigo colour, whereas at Cairo and occasionally in the Nile valley, the sky is often of a very pale blue.

The air has therefore a remarkable purity and clearness, producing a high power of diathermancy. At night the wind has fallen, any trace of cloud is gone, the clearness and stillness are unsurpassed, and dew is rarely observed, even should the freezing-point be reached. In the Libyan desert Rohlfs noted dew six times in seven months; mist was never seen. Rain, rare in the Sahara, is rarer still in the Libyan desert area, yet in 1874 the Rohlfs mission met with a deluge lasting three days, preceded by a violent tempest, the wind passing from South-west to North-west.

That the small amount of moisture in the form of rain or dew in the Libyan desert has been a condition present for all historic time, and probably far back into geological time is evidenced by: (1) The perfect preservation of sun-dried brick buildings of the Roman period in the Libyan desert, and of others dating back to 6000 years in Egypt, which would have been washed away rapidly in England; (2) The absence in the Libyan desert of marked erosion, which is common in other parts of the Sahara. Such erosions as do occur are largely due to the other causes of this condition, such as dissolved carbonic acid (*sic*) destroying the cements, temperature changes varying from 23° to 160°, and wind, the last factor, which has made the Libyan desert a sea of moving sand-dunes often 300 feet high, and even reaching 900 feet in height, and resting not on a base of quartz, but one of limestone; (3) The changes which long ages have been able to effect in the flora and fauna, evolving forms specially adapted to the dryness of the surroundings. The great heat and dryness has excluded the flora of the Mediterranean, and the coldness of the nights, a tropical vegetation. The existing vegetation is adapted to spring to life, flower, and fruit, in a very short time after a shower of rain, the leaves either falling off with the dryness, or replaced by spines impermeable to the drying effects of the air, or else they are very small, as in the tamarisk and the gum-acacia. The leaves may take a vertical position parallel to the sun's rays, or else the branches approach each other for a protection from the heat. The leaves, covered with bad conductors of heat, are folded, or secrete a volatile oil, internally; they may be filled with a mucilage tenacious of moisture, or the stomata may be closed at times with gum; sometimes the sap is saline. On rocks in the desert, absolutely without water, plants exist, so that Rohlfs believed they must obtain water from the air, and plants, such as the *Reaumuria hirtella*, have been seen covered with minute drops of water, which have been replaced at sunrise by minute crystals of salt produced by the plant, when no dew was deposited elsewhere, thus actually obtaining moisture from the air itself.[1] As regards the fauna, almost all desert animals can go for long periods without water, the camel on herbage alone will go for a month, and Rohlfs' camels took no water for eighteen days.

The temperature in the Libyan desert, which we have seen largely influences the amount of humidity in the air of Egypt, is colder than Cairo. The wind from the West and South-west in the months of January and February may be very cold, although in March and April it becomes a very hot wind, especially if more from the South. The daily variation of temperature in the Libyan desert was 35° (May 1879).[2] At Mourzouk 28° (from November to March 1865-6),[3] and 68° has been observed in Tripoli, the minimum being 31° (December 25, 1879),[4] and 58° at Toro near Borkou (May 15, 1871).[5]

Captain Lyons, R.E., in the Nubian desert near Murat Wells, gives me for December 10, 11, 12, 1894, a variation of only 17°. The Medical Department of the Egyptian War Office have kindly furnished me with the temperatures at Korosko and Khargeh, which for November 1894 show a mean daily range of 34° at Korosko, and of 32° at Khargeh.

The annual variation, or difference of the means of the coldest and warmest months in the Libyan desert is as much as 29°, at Koufra the mean of January 1879 being 56°, and that of August 85°.[6] As an absolute minimum temperature 23° was noted in the Libyan desert in 1874,[7] and water often freezes at night. As an absolute maximum 122° in the shade may be taken as authentic,[8] giving a variation for the year of at least 90°.

[1] Volkens, *Die Flora der Aegyptisch-Arabischen Wüste.* Berlin, 1887.

[2] Rohlfs, *Kufra.*

[3] Rohlfs, *Reise durch Nord-Afrika.*

[4] Rohlfs and Stecker, *Kufra.*

[5] Nachtigal, *Sahara und Sudan.* Leipzig, 1879.

[6] Rohlfs, *Kufra.*

[7] Jordan, *Physische Geographie der Libyschen Wüste.* Cassel, 1876.

[8] At Soûf, "Escard, Étude médicale sur l'oued-Soûf," *Arch. med. mil.* 1886.

Climate of Nile Valley.

Having referred briefly to the climate of the Libyan desert, we shall now discuss the conditions present in that part of the desert through which the Nile flows.

Egypt consists of the broad Delta and the narrow Nile valley, and is everywhere flat. From the base of the Delta to Cairo, at the apex, is about 130 miles, thence the Nile valley extends to the south in a direction north and south to Assiout, then south-east to Guerga, then due east to Kench, then south again. The valley is bordered on either side by a low range of flat-topped cliffs of nearly uniform height, the plateau above extending away at varying levels in undulating desert. The river follows the winding curves marked out by the cliffs, as a rule nearer the eastern than the western cliffs; but at Luxor and Assouan the river approaches the western cliffs. The cliffs average 300 feet in height, though at Thebes they reach four times that height. Between the hills the cultivated Nile valley occupies about two-thirds of the extent, the remainder is desert. The mean breadth of the Nile is one-half to three-quarters of a mile, varying with the time after the flood.

The Nile commences to rise about the last week of July, rises rapidly till the middle of August, and the remaining third of the rise takes another month or six weeks until the end of September. During October, Upper Egypt, as far north as Cairo, is under water, the basins being filled from the Nile. In the Delta the canals are full, but the water on the surface is less in amount than in Upper Egypt. About the second or third week of November, the Nile has fallen one-third of its usual rise, and two-thirds by the end of December. The rise is 40 feet at the first cataract, 36 feet at Luxor, 25 feet at Cairo, and 4 feet at Rosetta and Damietta.

The climate of Egypt during the winter is influenced by: (1) The Libyan or Western desert; (2) The Mediterranean Sea; and we shall endeavour to show that there is a third factor, the extent of cultivated land. To obtain some idea of these respective influences, we shall consider the climate of (1) *Alexandria*, under the influence of both sea and desert in the winter months; (2) *Cairo at the apex of the Delta* under the influence of desert to some extent, and also the modifications brought about in the sea-air by the intervention of 130 miles of cultivated land; (3) *Stations near Cairo:* (*a*) Helouan, on the east side of the Nile, 15 miles south of Cairo; (*b*) Mena House, near the Great Pyramid, on the west side of the Nile, and 8 miles from Cairo, on the edge of the desert; (4) *Stations in Upper Egypt:* (*a*) Luxor, with adjacent stations; (*β*) Assouan at the first cataract.

I shall base my remarks on the climate of Alexandria and Cairo on the report for the five years 1886-90, prepared by Dr. Engel Bey for the Egyptian Government, which is a résumé of the observations taken for those years, by Esmatt Effendi, at the Khedivial Observatory at Abassiyeh, situated about a mile and a half in the desert north-east of Cairo, the cultivated land being half a mile distant on the north side. The station was 40 feet above the ground under a kind of covered verandah, and may be considered as intermediate between the actual climate of Cairo, and a place situated in the East desert, some few miles to the south of Cairo. The observations at Alexandria were taken on the roof of a house in the town by M. Pirona for the Central Meteorological Institute of Vienna.[1]

The differences between the two places are very remarkable, and characteristic as to the daily and seasonable variations. The temperature of Cairo is much higher in the summer and a little lower in the winter than that of Alexandria. The relative humidity varies much more at Cairo, but in the inverse direction, being much lower at Cairo in the summer, and a little higher in the winter than at Alexandria. The absolute humidity is far greater at Alexandria than at Cairo, but descends rapidly in the winter to about the same level. The rain and the force of wind are much greater at Alexandria than at Cairo. The climates of Alexandria and of Cairo with mean annual temperatures (five years) of 69° and 70°·4 are subtropical, yet the former is characterised as being a maritime, and the latter, although only a small distance from the sea, as a continental climate; both, however, are seen to be under the influence of both desert and sea.

Cairo.

The mean temperature is 70°·4, slightly varying from year to year.

The mean daily variation is 25°.

The mean absolute maximum is 112°, the mean absolute minimum is 36° (for five years). The absolute maximum was 118°, and the absolute minimum 34°.

The temperature descends gradually from the maximum of the 30th week of the year, by even stages, to the minimum in the 4th week of the following year.

The stability of the temperature is very marked in winter and autumn, in the spring rapid changes take place at irregular intervals, the temperature rising suddenly only to fall again, notably at the period of the 50 days ("Khamseen") between the Coptic Easter and Pentecost, characterised by winds of that name from the South and South-west, which are preceded by a barometric depression and bring excessive heat, varying from 100° to 108°, and marked dryness, with fine sand in clouds from the desert, hiding the sun or rendering it a dull yellow colour. A Khamseen lasts from 2 to 4 days, the change following is abrupt, the wind passing to the North-west or West with increased barometric pressure and relative humidity, and a much lower temperature. Occasionally storms occur at this time. The relative humidity is often lowered during a Khamseen to 10 or even to 3 per cent.

The mean daily variation of temperature in winter is about 22°, but during a Khamseen the differences may reach 42°, 47°, and even 51°.

The least daily variations are in winter, owing to the maximum keeping low. It may be only 9°—even 7° has been noted.

The absolute humidity for the year is relatively high, ·425 in.; it is least in the winter.

The relative humidity is 61·2 per cent; it is lowest in June, and then rises till the end of December, slowly falling again, about 6 per cent per month, till the end of March.

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[1] *Jahrbücher der K.K. Central Anstalt für Meteorologie, Wien.*

At the time of the inundation, the absolute humidity increases, and, the temperature being stationary, the relative humidity is higher.

Alexandria.

The mean temperature is 69°. Maritime conditions give a smaller range to both temperature and relative humidity.

The temperature is lower in summer and higher in winter than at Cairo.

The mean daily variation (five years) is 8° (Cairo 25°). The marked daily variations are, as at Cairo, the most frequent between March and June (the period of Khamseen), but they are more frequent at Cairo in February, and at Alexandria in March.

The mean winter temperature is 60° (Cairo 59°), from December to March; the sea overbalancing in its influence the colder South-west winds from the desert. This is affected by a lowering of the temperature by day, and an increase in the temperature by night at Alexandria as compared with Cairo, but the difference is more due to a raised minimum than to a depressed maximum, the minimum being raised by three times the amount that the maximum is depressed.

From the middle of February to the first week in November the mean temperature of Alexandria descends below that of Cairo, and in summer the mean maximum of Alexandria is actually below the mean of Cairo; in winter the mean minimum of Alexandria is equal at times to the mean of Cairo.

The absolute humidity increases much more rapidly in the spring than at Cairo, reaching its maximum in July with the temperature. It falls as quickly, the influence of the sea, which had been partly overcome in the winter by the South-west desert winds, being re-established with the prevailing North wind of summer.

The relative humidity, instead of falling in spring as at Cairo, rises slowly to July, then falls gradually below the level of Cairo till the following spring.

In October, with the high Nile, comes a slight increase of temperature, and of relative and absolute humidity; the increase of humidity is also clearly seen at Cairo.

The mean annual atmospheric pressure is:—

At Cairo (100 feet) 29·56 ins.

At Alexandria (40 feet) 29·64 ins.

The pressure is highest in winter, being at Cairo 29·99 ins., and at Alexandria 29·97 ins.

At *Cairo* the mean annual direction of the wind is N. 14°·89 W. From May to October, the direction is almost exclusively North; at the end of October the atmospheric pressure rises over the Libyan desert for the winter, and the South-west winds show themselves occasionally, the Sahara being colder now so that we get a cold Khamseen (South or South-west). In spring the South-west wind is rarer, but comes as a hot Khamseen.

At *Alexandria* the mean annual direction is N. 35° W. The wind blows with far greater force than at Cairo.

Cloud is prevalent to an equal extent at both places.

At *Cairo* there are 17 days of rain a year, nearly all occurring in the winter or spring months. On many of these days only a few drops fall, the mean amount of these days being ·08 in.

At *Alexandria* there are 39 days on which rain is recorded, being more than double that of Cairo, while the amount of rain is 6 or 7 times as great as at Cairo.

Winter Climate.

The series of observations which I shall now bring before you was undertaken by me three years ago, and extends over the winters of 1893-94, 1894-95, and 1895-96, commencing generally in the month of November and extending to the end of March in Upper Egypt, and to April and May at the stations near Cairo. The object was to arrive at a comparative knowledge respecting the climates of the various stations now considered as health resorts in Egypt, and by a strictly comparable method to arrive at the precise differences between the climates of Upper and Lower Egypt, all previous observations having failed in this respect.

Stations, Instruments, etc.

The stations selected for observation were:—

(1) *Cairo*, 60 feet above the sea, during 1894-95, on a house close to the Hotel Continental, during 1895-96 again on the flat roof of a house and near the Kasr-el-Aini Hospital. There was no cultivated land nearer than one mile, and this was situated on the other (west) side of the river.

(2) *Helouan*, 115 feet above the cultivated land, and 15 miles south from Cairo in the eastern desert. The cultivated land is about 2 miles to the west.

(3) *Mena House Hotel*, 8 miles from Cairo at the apex of the Delta, is 300 yards to the north of the Great Pyramid, in the western desert, and about 20 to 30 feet above the cultivated land, and about 100 yards from the cultivation. On its western side the desert sand-hills rise rapidly to a height of 100 to 150 feet. The edge of the desert, defining the cultivated land, stretches away to the north and then to the north-west.

(4) *Luxor*, 450 miles south of Cairo on the right bank of the river, 241 feet above the sea. The roof of the Luxor Hotel is about 60 yards south-east of Luxor temple, on the south edge of the town. An occasionally watered garden surrounds the hotel. The town with the cultivated land beyond intervenes on the north side between the hotel and the river. The hotel is separated from the river on the west by 100 yards of cultivated land.

(5) *Assouan* on the north side of the first cataract. The Assouan Hotel is on the front of the right bank of the river; immediately opposite the western cliffs come close to the river. There is no cultivated land within 300 yards on the north side of the town. The prevailing wind from North-west or North comes straight up the river to the town.

(6) *Luxor Fields*, a subsidiary station, half a mile south of the town, 5 feet above the ground in the growing corn.

(7) *Luxor Desert West*—subsidiary stations:—

(*a*) In the *desert portion of the Nile valley* at varying distances from the Nile valley.

(β) On the *south side of the Valley of the Tombs of the Kings*, 2 to 3 miles from the Nile valley and removed from its influence. The position being only 8 feet from the vertical entrance to a royal tomb, hollowed out of the limestone hill rising abruptly on the south side of the valley, was such that the direct sun's rays did not fall on the screen. A reading of the dry bulb in the screen in this position, and one with the screen removed into the vicinity with the sun's rays directly on the screen, gave a difference of + 4° in the latter case.

(γ) *The crest of the Libyan Hills.*—This was a point situated 300 to 400 feet above the Nile valley on a promontory jutting out to the east and looking into the Nile valley. The view from this point was unobstructed for three-fourths of a circle, but was blocked to the west, the hills rising still higher.

There was no cliff which could act as a side reflector, except one 30 yards to the west. The position may be considered as "exposed."

In the case of stations (1) to (5), 40 to 50 feet must be added to any elevation given to allow for the mean height of the buildings on which the screens were placed.

All the observations (except those of the subsidiary stations near Luxor) were taken on the flat brown cement roofs of hotels from 40 to 50 feet high. The roof of the Assouan Hotel was of brick. There were no walls which could act as reflectors in the neighbourhood, and comparable sites were selected towards the north on each roof.

The screens containing the instruments were of single louvred sides, partly after the pattern of the Stevenson screen, the portions of the louvred sides sloping downwards and outwards. The roof was single, sloping towards the north and projected slightly. The wood was ¾ in. thick in the roof and floor. The screens measured internally 28 inches long, 14 inches deep, and 14 inches high, and stood 5 feet above the roof. The door of the screen opened towards the north in all cases.

The instruments consisted of six sets of self-recording thermometers and hair-hygrometers made by Richard Frères of Paris; all were carefully examined and regulated in one room in Cairo for a week before being placed at their respective stations.

The standard dry and wet bulb thermometers used at each station for regulating the recording instruments were made by Casella of London.

One recording thermometer and one hygrometer were placed in each screen, with the standard thermometers. The dry and wet bulb thermometers were on one "fixture" and more than 4 inches apart, and in taking a reading the "fixture" was placed almost vertically leaning against the outer case of the recording thermometer at the east end of the screen, and looking towards the north. The screen was closed for 10 minutes before the reading was taken.

The possibility of carrying out so extended a series of observations is due to the kindness of several friends resident at the different stations, and I take this opportunity of expressing my thanks to Mr. Longmore, M.R.C.S., and Mr. Jalland, M.B., resident at Assouan; to Dr. Bentley and Mr. J. L. Hichens at Mena House; to Dr. Kaufmann at Cairo; to M. F. Douat at Helouan; and also to Dr. Page May, for kind assistance. The cost of instruments was defrayed by Messrs. Cook, Pagnon, Suarez, and the author.

It was found that any attempt to secure comparable sites, oth[illegible]r than those selected on the roofs of buildings, was futile. In discussi[illegible]g the influence of cultivated land, it will be seen that the presence [illegible]or absence of cultivation in the immediate neighbourhood gives wide[illegible]ly different results.

Interpolations.—112 temperature readings out of over 13,000 readin[illegible]s, and 340 relative humidity readings out of over 15,000, have been int[illegible]erpolated; these were calculated on the readings for the corresponding ho[illegible]ur for three or four days before and after, regard being paid to any speci[illegible]ia conditions present on the day itself at other hours, if recorded.

Temperature.

The recording thermometers were found to act remarkably we[illegible]ll, rarely, if ever, requiring readjustment.

From the continuous tracings of temperature it has not been possib[illegible]le for three years to give an average for the whole of the four wint[illegible]er months at each of the four principal stations, certain months being fou[illegible]nd not quite complete.

Tables III.-VII. (pp. 192-194) have been drawn up to show su[illegible]ch periods as are comparable at the different stations. The figures f[illegible]or Mena House and Helouan, representing Lower Egypt, will be found [illegible]t correspond closely owing to their proximity to each other; certain poin[illegible]t of difference, however, will be drawn attention to later in discussing t[illegible]h minima. Luxor and Assouan will represent Upper Egypt.

It will be seen (Tables IV.-VII.) that the mean temperature for thr[illegible]e years of the four months, December to March, at Mena House (Decemb[illegible] being only for two years) was 59°·5, at Helouan (two years only) 60°·5, [illegible] Luxor 63°·8, at Assouan (January and March two years only) 68°·[illegible] These figures will be seen (Table IV.) to correspond closely with tho[illegible] given for two years only, and also with those (Table III.) given for a[illegible] entire comparison of four months at the four stations for 1895-6 onl[illegible] The winter of 1895-6 is seen to be 0°·5 cooler than the mean.

It will be observed from the following Table (A) for the four month[illegible]

TABLE (A).

Station.		Min.	Max.	Mean.
Lower Egypt	Mena (Table V.) .	48°·7	70°·4	59°·5
	Helouan (Table IV.) .	49·4	71·7	60·5
Upper Egypt	Luxor (Table VI.) .	49·6	78·1	63·8
	Assouan (Table VII.).	54·5	82·1	68·3

December to March that Helouan has a mean temperature 1° warmer than Mena House, Luxor 3°·3 warmer than Helouan, and Assouan 4°·5 warmer than Luxor.

The mean minimum for the same period was 0°·7 warmer at Helouan (two years only) than at Mena House (three years), Luxor (three years) was 0°·2 warmer than Helouan, and Assouan (three years) 4°·9 warmer than Luxor.

The mean maximum for the same period was 1°·3 warmer at Helouan than at Mena House, Luxor was 6°·4 warmer than Helouan, and Assouan 4° warmer than Luxor.

From table (B) we observe that there is a fall of mean temperature in January, which is less marked in Upper than in Lower Egypt, being least at Assouan.

TABLE (B).

Station.		Years.	Jan.	Feb.	March.	April.
Lower Egypt	Mena .	1893-94, 1895-96	-4·5	+3·0	+3·1	+5·2
	Helouan .	1894-95, 1895-96	-3·5	+5·4	+2·2	+8·4
Upper Egypt	Luxor .	1893-94, 1894-95, 1895-96	-2·7	+3·6	+6·6	...
	Assouan .	1894-95, 1895-96	-1·8	+5·0	+6·5	...

In February the temperature rises less relatively at Mena House and at Luxor than at Helouan and at Assouan; in March there is a further rise which is more than twice as great in Upper as in Lower Egypt. March in Upper Egypt is 8°·6 warmer than December, but in Lower Egypt it is only 2°·8 warmer.

Table (C) shows the progress of the mean maxima from month to month, the additions or subtractions being as in the previous tables to the temperature of the month immediately preceding; we see there is a reduction of the mean maximum in January, which is greater in Lower Egypt than in Upper Egypt, being least at Assouan. In February there is a considerable increase throughout Egypt, though to a less extent at Mena House and Luxor, probably due to the neighbouring cultivation. In March the maximum is still increased, to about twice the extent in Upper Egypt as compared with Lower Egypt. In April in Lower Egypt there is a large increase in the mean maximum corresponding to the large increase in Upper Egypt in March.

TABLE (C).

Station.		Years.	Jan.	Feb.	March.	April.
Lower Egypt	Mena .	1893-94, 1895-96	-4·8	+4·5	+4·0	+5·5
	Helouan .	1894-95, 1895-96	-3·0	+6·4	+2·7	+9·5
Upper Egypt	Luxor .	1893-94, 1894-95, 1895-96	-2·1	+4·4	+7·0	...
	Assouan .	1894-95, 1895-96	-1·5	+6·7	+6·1	...

Table (D) shows the differences in each month on the previous month in the mean minimum, and it will be observed that the minimum falls in January by about 4°, except at Assouan, where it falls only 2°. In February it rises to about the same extent, but the rise is least at Mena House; in March a further rise takes place 3½ times as great in Upper as in Lower Egypt. In April there is a large rise in Lower Egypt corresponding to that of Upper Egypt in the previous month. It must be noted that the periods selected are not strictly comparable, except in the case of Helouan and Assouan in the three tables (B) (C) and (D).

TABLE (D).

STATION.		Years.	Jan.	Feb.	Mar.	April.
			°	°	°	°
Lower Egypt	Mena . .	1893-94, 1895-96	-4·3	+1·5	+2·2	+4·8
	Helouan .	1894-95, 1895-96	-4·0	+4·3	+1·7	+7·3
Upper Egypt	Luxor .	1893-94, 1894-95, 1895-96	-3·5	+3·0	+6·2	...
	Assouan .	1894-95, 1895-96	-2·0	+3·3	+6·7	...

If we compare in these tables the total increase of temperature for the first three months of the year with the means of December, we find that as regards the maximum and minimum they have advanced at Mena House 3°·7 and – 0°·6 respectively, at Helouan 6°·1 and 2°, at Luxor 9°·3, and 5°·7, at Assouan 11°·3 and 8°. In other words, if we take the mean of the advance in Lower Egypt, it is 4°·9 in the maximum and 0°·7 in the minimum; whereas in Upper Egypt the mean of the advance is 10°·3 in the maximum and 6°·8 in the minimum. The rise of the minimum in Lower Egypt is very small, and there is even a retrocession at Mena House; this disproportionate advance of maximum and minimum is less marked in Upper Egypt, especially at Assouan, where the proportion is as stated. If we include the month of April, the advances are at Mena House in the maximum 9°·2, in the minimum 4°·2, and at Helouan 15°·6 and 9°·3. The figures referred to in these tables are of importance in tracing the effect of vegetation upon the course of the temperature, and reference will again be made to them.

In Table VIII. we find the mean differences between the highest and lowest mean daily temperatures in the respective months give for—

December . . .	Lower Egypt, 16°·7	Upper Egypt, 18°·5
January . . .	,, 17°	,, 17°
February . . .	,, 22°·5	,, 20°
March	,, 17°·5	,, 26°·5

The marked variation of the month of March in Upper Egypt is occasioned by the occurrence of the hot Khamseen winds. The maximum variation in the extremes of the daily means of any month was 29°, and occurred at Assouan in February 1896 and March 1894, and also at Luxor in March 1894. The corresponding minimum variation at Mena House in February 1894 was 10°.

The highest mean daily temperature in the three years was 93° at Assouan on March 23, 1896, the lowest 48° at Mena House January 22, 1896. The means of the absolute maximum for the respective months were:—

December . . .	Lower Egypt, 81°·7	Upper Egypt, 88°·3
January	,, 77°·2	,, 87°·3
February . . .	,, 91°·7	,, 97°
March	,, 89°·9	,, 105°

The absolute maximum occurred on March 22, 1894, at Assouan, 109°, being at Luxor 5° lower on the same day. The maximum for the same month at Mena House was on the same day, and was 17° lower than at Assouan.

The means of the absolute minimum for the respective months were :—

December . . .	Lower Egypt, 41°·5	Upper Egypt, 41°·5
January . . .	,, 37°·8	,, 40°·1
February . . .	,, 42°	,, 43°·8
March	,, 44°·4	,, 47°·5

The absolute minimum was 37°, and it occurred at Mena House on January 6, 1895, and on January 21, 1896, at Helouan on January 6, 1895, and at Luxor on January 5, 1895. At Assouan the lowest temperature was 41°.

Lower minima were recorded at the station in the fields near Luxor, which will be referred to later on.

The Range or Mean Daily Variation of Temperature (*Tables IV.-VII.*).

For the four months (December to March) this was found to vary considerably. In Lower Egypt for these months it was 21°·7 at Mena House, and 22°·3 at Helouan, being least in December (19°·3), and increasing to April (26°·5) at Helouan.

In Upper Egypt it was greater, being 28°·4 at Luxor and 27°·6 at Assouan, advancing as in Lower Egypt from 25°·6 in December to 30°·1 in March. The greatest mean monthly range was 33°·1 for February 1895 at Luxor, the smallest 18° at Mena House for January 1896.

The absolute monthly range (Table VIII.) was larger in Upper than in Lower Egypt, being in—

December . . .	Lower Egypt, 40°·2	Upper Egypt, 46°·8
January	,, 39°·5	,, 47°·2
February . . .	,, 49°·7	,, 53°·2
March	,, 45°·5	,, 57°·5

The greatest monthly range was 66° in March 1894 at Assouan, and the least, 32°, at Mena House in December 1895. It will be observed that the wide ranges occur in February in Lower Egypt, and in March in Upper Egypt, being caused by the advent of Khamseen winds.

Table II. shows the mean monthly temperature at every two hours at six stations in the winter of 1895-96, the months being complete, except where noted to the contrary. It will be observed that the months of December and January closely approach in temperature at Mena House and Helouan, but in February and March Mena House is certainly colder than Helouan, and it has been seen that this is due in part to a lower maximum and partly to a more depressed minimum. At the hours of 8 and 10 a.m., and at 4 p.m., the difference is decided, and it is caused at 8 and 10 a.m. by the occasional presence of mist over the cultivated land in the neighbourhood of Mena House obstructing the sun's rays. At 4 p.m. the cause is the rapid cooling of the neighbouring fields when the sun passes behind the hills to the west of Mena. It is from 6 p.m. to 6 a.m. in the months of February and March that the great difference in temperature between these two stations is reached, being about 2° in the mean warmer at Helouan than at Mena House. In the previous two months (December and January), for the same hours Mena House was in

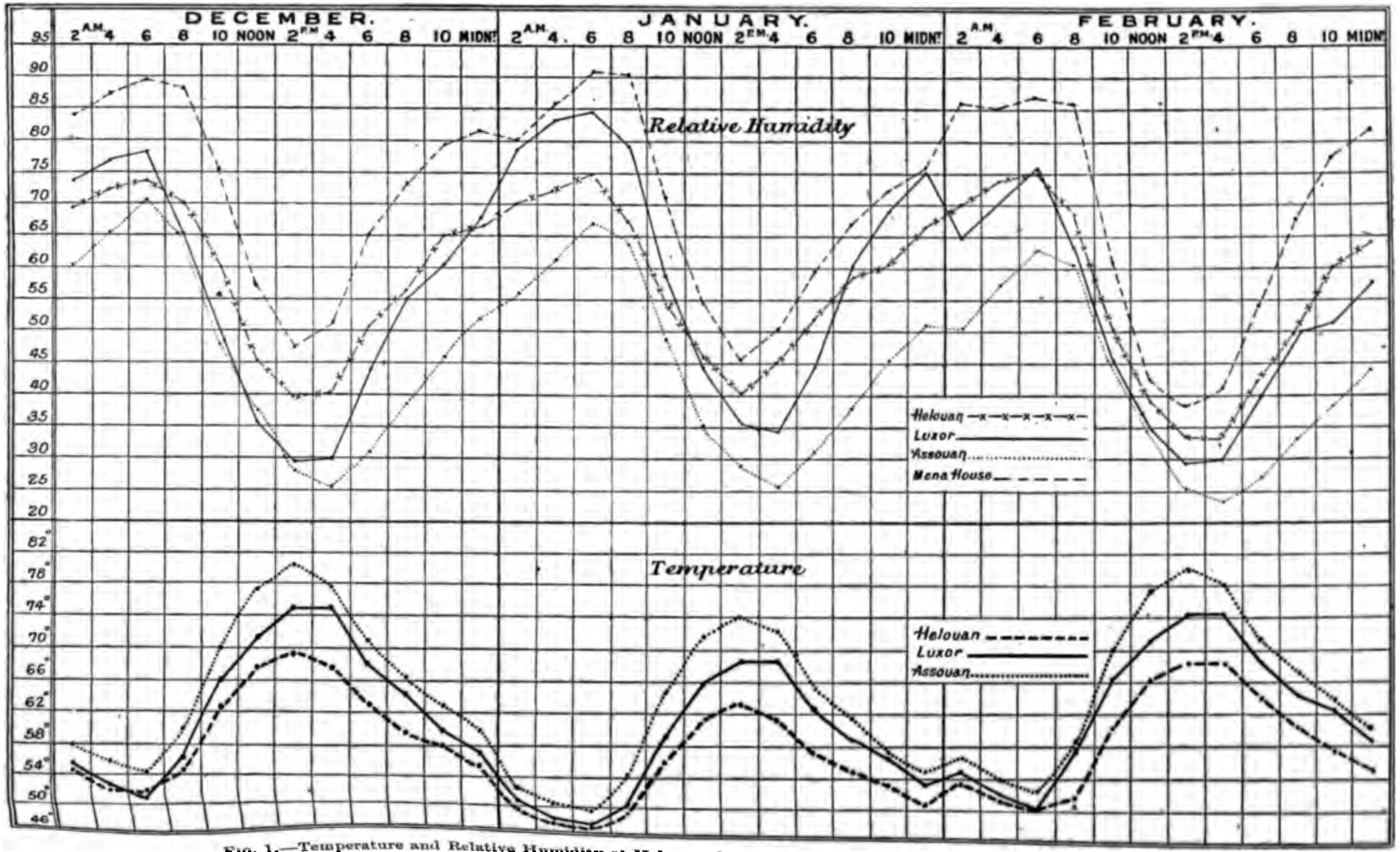

FIG. 1.—Temperature and Relative Humidity at Helouan, Luxor, and Assouan, December 1895 to February 1896.

the mean 0°·5 warmer than Helouan. The height of the crops in February and March in the neighbourhood of Mena House is the agent in reducing the minimum temperature.

The course of the temperature for three months at three of these stations (Helouan, Luxor, and Assouan) is shown in Fig. 1. In this year the mean temperature every two hours for the four winter months varied according to the following Table (E), the figures being the number of degrees to be added to the temperature of the station with which each station is compared.

TABLE (E).—DECEMBER TO MARCH 1895-96.

STATIONS.	2 A.M	4	6	8	10	Noon	2 P.M	4	6	8	10	Midn	Mean.
Helouan compared with Mena	0°·5	0°·3	0°·5	1°·4	1°·5	1°·0	0°·9	1·2	0°·9	1°·0	1°·2	1°·0	+0°·9
Helouan (Jan.-Mch.) compared with Cairo	1·7	1·5	1·4	2·5	2·3	1·0	0·6	1·[illegible]	1·3	1·5	2·0	1·8	+1·6
Luxor compared with Helouan	2·1	1·3	0·4	3·8	5·0	5·5	6·6	7·8	5·9	5·1	4·2	3·0	+4·3
Assouan compared with Luxor	2·4	2·9	3·0	3·5	4·8	6·0	5·4	3·3	2·6	1·2	2·4	2·5	+3·3

In the first three months of the year 1896, Cairo (on the roof of a house near the Kasr-el-Aini Hospital with no cultivation near) was 1°·6 colder than Helouan. The difference was, as at Mena House, most marked at 8 and 10 a.m. and at 4 p.m.; and at night Cairo was much colder than either Helouan or Mena House. Mena House, by its position on the edge of the desert, would, on still nights or with a light breeze from the West, be warmer than Cairo, which is more surrounded by cultivation, especially to the west. The course the depression of temperature at night takes at Cairo, lasting up to 10 a.m., corresponds to that due to the influence of cultivation, as seen at Luxor Fields (Table (F)) station, and is also marked at Mena House.

The Table (F) shows the differences of temperature taken every two hours during January and February 1896, and also from March 17 to 23, 1896, the latter period being after, or during, the gathering of the harvest, as compared with the station "Luxor Hotel Roof."

TABLE (F).—"LUXOR FIELDS" COMPARED WITH "LUXOR HOTEL ROOF."

TIME.	2 A.M.	4	6	8	10	Noon.	2 P.M.	4	6	8	10	Midn.	Mean.
an. and eb. 1896	−11°·0	−10°·5	−10°·0	−8°·0	−4°·0	−2°·5	−2°·5	−2°·5	−6°·0	−9°·5	−10°·5	−9°·5	−7°·2
arch 17-23, 1896	−6·5	−6·0	−3·0	+3·0	+4·0	+4·0	+2·5	+1·0	−5·5	−5·5	−4·5	−7·5	−2·0

"Luxor Fields" station was half a mile south of the hotel, and half a mile east of the river, standing 5 feet above the ground and in the growing corn; the surrounding country was fully cultivated, and no house was nearer than 500 yards; no irrigation of the land took place in the immediate neighbourhood. On January 1 the corn was 10 inches high, 10 to 15 yards to the north was a patch of beans 2½ feet high. The instruments in the cornfield and on the hotel were standardised daily. Mr. Chapman, of the Public Works Department, estimated that at the commencement of January the Nile was 6 yards below the bank, and the Nile water would be met 5 yards below the soil at the "Luxor Fields" station, at 4 yards the soil would be thoroughly soaked, and would be damp the rest of the way to the surface, with the exception of the upper six inches which were dry and broken up. On March 2 the corn was up to the legs supporting the screen. The differences in the Table (F) were + or − those recorded on Luxor Hotel Roof.

This Table (F) is important to demonstrate the very large influence of local conditions, especially in cultivated areas, in modifying the temperature. It must be noted that these wide differences are in the mean, wider differences occurring occasionally. The stations were half a mile apart only. The differences were greater by night than by day, being greatest at 2 a.m. during the period of cultivation, and at midnight during the harvest period. In the cultivated period from noon to 4 p.m. the fields are only 2°·5 cooler than the roof, but after sunset at 6 p.m. 6° cooler. During, or after the harvest, a great change takes place from soon after sunrise till sunset, the dry uncultivated fields are considerably warmer than the roof, reaching 4° difference between 10 a.m. and noon. After sunset to 6 p.m. there is the same difference as before, thence to 4 a.m. the difference is only half that during the crop time, and at 6 a.m. only one-third. At 8 a.m. the greatest change has taken place, the fields which were during cultivation 8° cooler than the roof, are now 3° warmer.

Thus we see that the growing crops depress greatly the whole night temperature, and therefore the minimum, and this depression lasts till 10 a.m.; they also depress the maximum, though to a much less extent (⅕).

During the cultivated period the mean temperature was 7°·2 less, and during or after harvest only 2° less than on the roof.

The range of temperature in the cultivated fields was 32° for January compared with 24°·5 on Luxor Roof; 36° in February compared with 26°·5 on Luxor Roof. The greatest daily variation was 50° on February 24 and 28, 1896, this was the greatest recorded in Egypt in the three winters. The least was 13° on January 17 and 18, 1896. The monthly mean temperature was 6° cooler in January and 7° in February than Luxor Roof.

The mean minimum temperature in January was 36°, or 9°·5 cooler than the mean minimum of Luxor Roof, and in February 37°·5, or 11°·5 cooler.

The absolute minimum was 29° on January 11 and 12, 1896; 30° was recorded on February 4 and 17, being the lowest temperature recorded in Egypt in this series of observations. The freezing-point was reached ten times in January and seven times in February.

The mean maximum temperature was 68° in January and 74° in February, both being 2° lower than the corresponding temperature of Luxor Roof.

To indicate the difficulty in obtaining comparable sites in Egypt, Table (G) is given showing simultaneous observations taken at Luxor Hotel on March 27 and 31, and April 1 to 5, 1894:—(1) On the *Luxor Roof;* (2) under the *northern verandah* of the same building, the verandah being a thick mud-brick construction, 50 feet long, 8 feet wide, and 14 feet high, supported by arches and pillars, and obstructing the direct sun's rays at all hours. Beyond the asphalt floor under this verandah was a bed of grass 10 or 12 feet broad frequently watered, and beyond this again other beds occasionally watered, and sand-walks; (3) *Luxor garden*, this position was on a sand-walk 4 feet broad, about the middle of the garden on the south side of the hotel, and 40 paces from the hotel. The palm trees above threw a broken shade on the Stevenson screen. Less than half the garden consisted of sand-walks, and the remainder of beds for flowers, irrigated by flooding on March 31 only. During the remainder of the time of observation, the surface was dry or drying.

TABLE (G).

1894.	Roof.				Northern Verandah.				South Garden.			
	Max.	Min.	Mean	Range	Max.	Min.	Mean	Range	Max.	Min.	Mean	Range
March 27	83°	58°	70·5°	25°	78°	61°	69·5°	17°	78°	53°	65·5°	25°
,, 31	80	51	65·5	29	73	53	63·0	20	72	48	60·0	24
April 1	89	54	71·5	35	79	56	67·5	23	81	50	65·5	31
,, 2	93	60	76·5	33	81	61	71·0	20	86	55	70·5	31
,, 3	104	63	83·5	41	91	60	75·5	31	95	59	77·0	36
,, 4	102	66	84·0	36	91	67	79·0	24	96	61	78·5	35
,, 5	88	72	80·0	16	84	73	78·5	11	83	68	75·5	15
Means	91·3	60·6	75·9	30·7	82·4	61·6	72·0	20·8	84·4	56·3	70·3	28·1
Difference compared with Luxor Roof.	–	–	–	–	– 8·9	+ 1·0	– 3·9	– 9·9	– 6·9	– 4·3	– 5·6	– 2·6

The deep shadow of the north verandah, and the partial shadow of the trees, together with the absence of reflected heat from the cement roof, account for the differences of the maxima. The minimum is depressed about ½ or ⅔ of the extent which might have been expected in the fields at this time. The mean temperature in the south garden was 5°·5 cooler than on the roof.

Comparative observations were taken, for certain periods, in the desert on the west side opposite Luxor. At the site described above as "Crest of the Libyan Hills" (7·γ) for fourteen days from December 26, 1893, to January 8, 1894, the following mean results (Table (H)) were obtained; the mean results for Luxor and Assouan Roofs for the same period are also given.

TABLE (H).

STATION.	Min.	Max.	Mean.	Range.
Crest of Libyan Hills	51°	65·5°	58·2°	14·5°
Luxor . . .	42	72·5	57·2	30·5
Assouan . . .	46	71·0	58·5	25·0

We have noted that this station was 300 to 400 feet above the Nile valley and overlooking it, separated from the cultivated land by a third of a mile of desert, exposed entirely to the wind from the north-west and north which prevails here as at Luxor, but which on this side of the river will have passed over at least 50 to 60 miles of desert, to the north, and a far greater extent to the north-west, the river and cultivation north of this point taking a long bend to the east. The results are remarkable. The mean minimum was 5° higher than at Assouan, and 9° higher than at Luxor Roof. The mean maximum was 7° lower than on Luxor Roof, and 5°·5 lower than at Assouan. The mean temperature was 1° warmer than at Luxor, and the range was only 14°·5. It would appear that, as far as the minima are concerned, the positions at Luxor and at Assouan are both under the influence of the lower strata of air, which, over the cultivated land, and to a less extent over the river, are much colder than the air of the desert at night. The air over the river is probably about the same temperature at night as that over the roofs of buildings adjacent. During the period of observation on the Libyan Hill Crest there was a considerable amount of wind at most times of the day, and for one night in three it blew very strongly, from soon after sunset till 2 a.m., as indicated by vibration of the recording pen.

The next desert station was (7·β), the *Valley of the Tombs of the Kings;* the Table (I) shows that for the comparable periods, the Valley of the Tombs of the Kings was in the minimum 4° warmer than Luxor Roof, and 3°·7 cooler in the maximum. This difference in the maximum would disappear if the Stevenson screen had stood in the sun's rays, 4° being the correction for shade here: therefore the valley of the Kings' Tombs had practically the same maximum, and the range was 4° less than at Luxor. The absolute minimum was 44°. It will be noted that if we add the correction for shade, the maximum would be the same at both places in February, 2° lower in the valley in January, and 3° warmer in March.

TABLE (I).

1894.	Luxor Roof.				Valley of the Tombs of the Kings.			
	Min.	Max.	Mean.	Range.	Min.	Max.	Mean.	Range.
	°	°	°	°	°	°	°	°
Jan. 9-31	45	73	59·0	28	49	67	58	18
Feb. 1-21	48	76	62·0	28	52	72	62	20
March 0-25	57	88	72·5	31	61	87	74	26
Means	50	79	64·5	29	54	75·3	64·7	21·3

The third desert station was that described as (7·a) in the west portion of the Nile valley opposite Luxor, and consisted of two series: (1) December 8, 1894, to January 11, 1895, on the roof of a house (Abderrasoul) west of the Ramasseum, about 300 yards from the cultivated land, and 150 yards from the hills farther to the west; (2) January 12 to February 11, 1895, on the same side, a mile and a half in the desert west of Medinet Habou, the hills approaching the screen about 60 yards to the north, and 150 yards to the west. The screen stood on the limestone desert. The Table (J) shows that there is a difference of 8° at these stations and Luxor Roof in the minimum, but

TABLE (J).

STATION.	Luxor Roof.				Luxor Desert West.			
	Min.	Max.	Mean.	Range.	Min.	Max.	Mean.	Range.
	°	°	°	°	°	°	°	°
Dec. 3, 1894–Jan. 11, 1895	48	76	62·0	28	50	76	63	26
Jan. 12, 1895–Feb. 11, 1895	47	78	62·5	31	51	75	63	24
Means	47·5	77	62·3	29·5	50·5	75·5	63	25

the difference was twice as great at the station farther in the desert than at the nearer one. The maximum was the same at the first station, but 3° lower than Luxor Roof at the second station farther in the desert. The range was less than on Luxor Roof. Thus the maxima at the western desert stations near Luxor were slightly depressed in the open desert compared with Luxor Roof, and much depressed at the height of 300 to 400 feet. The mean minima were less depressed at the lower desert stations, and much less depressed at the higher station, than at Luxor Roof.

The lowest mean weekly temperatures (coldest week) in the four winter months were:—

1893-94.	Mena	3rd week of Jan.	53°
	Luxor	4th week of Dec., and also of Jan.	56
	Assouan	4th week of Dec.	55
1894-95.	Mena	1st week of Jan.	57
	Helouan	4th week of Dec.	54
	Luxor		58
	Assouan		59
1895-96.	Mena	4th week of Jan.	53
	Helouan	1st and 4th weeks of Jan.	54
	Luxor	2nd week of Jan.	56
	Assouan	1st week of Feb.	60

The last week of the year was, in two years out of three, the coldest week in Upper Egypt.

The daily course of the temperature at the various stations will be seen from Table II. and Table (K), the changes being indicated at every two hours. In addition to such curves, there are often changes of 1° to 2°, sometimes even 3° to 5° occurring at irregular times, due to some local movement of air not equally warmed. These variations were less frequent at Helouan and Assouan and in the desert than at the other stations. We see from Table (K) that, if in Lower Egypt we start from the minimum at 6 a.m. (before sunrise), 17°·2 in the mean (December to March) will bring us to the maximum at 2 p.m.; of this 2°·5 is added by 8 a.m., 7½° more by 10 a.m., 4°·7 more by noon, and 2°·2 more by 2 p.m. The reduction of temperature to the minimum is 1°·3 by 4 p.m., 4° by 6 p.m. (which includes the hour of sunset), 3°·5 by 8 p.m., 2°·4 by 10 p.m., 2°·1 by midnight and 1°·4 at 2 a.m., 1°·7 by 4 a.m., and 1°·2 by 6 a.m.

In Upper Egypt (Luxor Roof and Assouan), 25°·3 have to be reached by 2 p.m. It is observed that 6°·6 are added by 8 a.m., 9°·6 more by 10 a.m., 6°·2 by noon, and 2°·9 by 2 p.m. A difference, however, occurs in the downward course of the temperature; at 4 p.m. we find a diminution of 2°·1 at Assouan, whilst the reading at Luxor is the same as the maximum at 2 p.m. At 6 p.m. there is a fall of 6½°, at 8 p.m. 4°·9, at 10 p.m. 2°·6, at midnight 3°·4, at 2 a.m. 2°·6, at 4 a.m. 2°·8, and at 6 a.m. 2°.

From these figures it will be observed that in Upper Egypt the increase of temperature at 8 a.m. is greater proportionately than in Lower Egypt, which will be seen to be in relation to the lower relative humidity of Upper Egypt.

TABLE (K).—Showing the Mean Number of Degrees higher or lower than at the previous Observation for the Months of December 1895 to March 1896.

Hour.	Mena.	Helouan.	Luxor Roof.	Luxor Fields.	Assouan.
				Jan., Feb., Mar. 17 to 23	
	°	°	°	°	°
2 A.M.	− 1·2	− 1·7	− 2·6	− 3·4	− 2·7
4 ,,	− 1·6	− 1·8	− 2·6	− 1·5	− 3·1
6 ,,	− 1·3	− 1·1	− 2·0	− 0·5	− 1·9
8 ,,	+ 2·1	+ 3·0	+ 6·4	+ 9·9	+ 6·9
10 ,,	+ 7·7	+ 7·8	+ 9·0	+ 11·3	+ 10·3
Noon.	+ 4·4	+ 5·1	+ 5·6	+ 7·0	+ 6·8
2 P.M.	+ 2·2	+ 2·1	+ 3·2	+ 2·7	+ 2·6
4 ,,	− 1·5	− 1·2	...	− 0·7	− 2·1
6 ,,	− 4·0	− 4·3	− 6·2	− 10·8	− 6·9
8 ,,	− 3·5	− 3·4	− 4·2	− 6·2	− 5·6
10 ,,	− 2·5	− 2·3	− 3·2	− 3·3	− 2·0
Midnt.	− 2·0	− 2·2	− 3·4	− 4·5	− 3·3

The course of the temperature in the cultivated land is exhibited at Luxor Fields, where the range is 32° or 33°, and differs from Luxor Roof by the very rapid rise from 6 a.m. to 10 a.m., so that in four hours from the minimum a rise of 21°·2 has been attained; the course then follows that of Luxor and Assouan till 6 p.m., when in two hours it has dropped 10°·8, and this drop is still continued to 8 p.m. It then follows again that of Luxor and Assouan Roofs, with the exception that the approach to the minimum is more nearly reached by 4 a.m.

The increase of temperature from 6 a.m. to 10 a.m. is remarkable; in January at 8 a.m. 4½° are gained, and 14° more by 10 a.m.; in February the gains in these hours are 9½° and 13½°, and in March 15½° and 6½°, the occasional mists over the fields in January not clearing till 10 a.m., but in February and March they clear away earlier. The fall at 6 p.m. increases towards March, and that at 8 p.m. decreases to the same month. At Luxor Roof, the access of temperature at 8 a.m. is, in February and March, twice that of January, and the same is observed at Helouan and Mena House in Lower Egypt, but not till March.

With regard to the fall of temperature at sunset, much has been said by nearly every one who has ever travelled in Egypt, and it has often been described as very great. So far as these continuous observations show, the fall of temperature from 4 p.m. to 6 p.m. (including the hour of sunset) is only 1° more than that for the following two hours to 8 p.m. in Lower Egypt, whilst in Upper Egypt the fall from 4 p.m. to 6 p.m. is only 2° more than that for the following two hours. In the desert, the reduction of temperature from the maximum to the minimum is gradual, though rather more rapid up to 6 p.m. than after that hour.

In the cultivated land the fall from 4 p.m. to 6 p.m. is 11°, being three times that at Mena House or Helouan, and about twice that at Luxor Roof or Assouan, and under these conditions it is true that a very rapid cooling goes on; but even in this case, it is not all limited to the actual time of sunset. On examining the temperature curves more closely, we find that in the desert in Upper Egypt always, at Helouan generally, at Mena House frequently, on Luxor Roof generally, and at Assouan nearly always, the time of sunset is not marked by any appreciable extra fall of temperature, the downward curve is not disturbed. At other times, occurring as indicated, the exceptions take place, so that at Mena House a fall of 3° to 5° is frequently noticed in a quarter of an hour; at Helouan a fall of 1° to 2° might only occasionally be noted; a fall of 3° to 5° at Luxor, perhaps once a week, depending upon the presence of a breeze from the cultivated land, or exceptional conditions; and at Assouan a fall of 2° to 3° would be exceptional.

The sudden absence of the direct sun's rays at sunset gives the sensation of a fall of temperature, which, however, is nervous in origin, and produced by changes at the surface of the body. Dr. Marcet[1] has drawn attention to the length of time required after sunset before the sensation of "chill" is experienced.

It has been observed that the changes of temperature at sunrise are striking at all the stations, and at Helouan, Luxor "fields" and "roof," Assouan, and in the desert, sunrise is marked by a sudden steep rise from the minimum point, so precise, that in the case of one instrument, the clock of which was irregular, it has been possible by this means to estimate the error, when not noted otherwise.

General Conclusions on the Temperature.

The range of temperature will be controlled by the influences which affect the maximum and minimum. In Egypt the accession of temperature to the maximum is influenced mainly by the diathermancy of the air, which is directly controlled by the relative humidity. In the coldest month of the year, the access of temperature is slow. At stations such as Mena House and Luxor, though to a much less extent, the occasional mists of the early morning are late in clearing, owing to the influence of cultivation at either place. This condition, however, has in Upper Egypt almost entirely disappeared a few weeks later, and the access of temperature is then largely before 8 a.m. At stations where the influence of cultivation is slight, as at Assouan and Luxor, compared with stations such as Mena House, and to a less extent, Helouan (both the latter stations being influenced by the cultivation of the whole Delta, whereas Upper Egypt is mostly under the influence of the desert, and only a small strip of cultivated land), the approach to the maximum is earlier, and the curve remains longer at a high level than at the stations of Lower Egypt. The presence of cultivation, either in the immediate neighbourhood, as in the fields in still weather, or closely approximated, has the effect of rapidly reducing the temperature just before sunset and for the following two or three hours, and then maintaining a fall to a far lower minimum than at neighbouring stations less influenced by cultivation, so that a difference of 15° or even 20° may be found at 6 a.m. between stations only 3 miles apart. On still nights the effect of cultivation is closely limited to its own area, and may not affect the neighbouring road 6 feet above. It is probable that the lower temperatures do not extend much above the lower strata of air, as we have seen on the crest of the Libyan Hills overlooking the Theban plain.

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[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xi. p. 275.

These conditions are all changed if there be wind; then the night temperature at a given spot, depending upon cultivation, is not lowered to anything like the same extent if the wind is strong enough to bring in the desert air, the area of cultivation being small as in Upper Egypt.

But at certain stations situated, as Mena House, close to cultivation, and Helouan in the track of the wind from a very large area of cultivation—the Delta—the effect of a breeze from this direction would be the reverse, viz. to depress the temperature at night. At Luxor, the presence of cultivation to the north side of the town, the wind, if any, being from the north, influences that side of the town only, and does not extend over the half mile of sun-heated houses intervening between the north side of the town and Luxor Hotel, situated on the south side. Should the wind be strong enough to pour in this colder air from the north, it must inevitably bring in the warmer air from the desert. The cultivation 50 yards to the south of Luxor Hotel has probably no effect on the temperature of Luxor Roof, the prevailing wind being from the North or North-west. At an elevated station in the desert, near Luxor, we have seen that under the influence of the prevailing wind from the desert, the range of temperature was very small, and the minimum depressed only slightly.

Thus we see the immense influence of local conditions in Egypt on the night temperature; stations a long way off in the desert may, by the wind, be placed under the influence of cultivated land.

The presence of water in large quantity, as a river or lake, does not lower the temperature of the air at night so much as the presence of a small quantity of water, to effect the evaporation of which heat must be taken from the surrounding air, and the rapidity of evaporation in Egypt is more easily compensated for from a large amount of water at a relatively high temperature than from a very small amount protected from the sun's rays by growing crops.

The presence of high growing crops and a slightly humid broken-up soil, even though the soil be dry at the surface, affords in Egypt the best means of obtaining rapidly a low temperature after sunset and through the night. The very low relative humidity in the day tends to the evaporation of an enormous quantity of moisture from the fields; the heat required to effect this evaporation is obtained from the direct sun's rays. After sunset the evaporation has still to continue, though to a progressively less extent; the large supply of heat from the direct sun's rays has been removed, and the temperature of the earth has been little raised during the day, owing to the protection afforded by the crops, hence the heat required must be taken from the lower strata of the air.

Equally powerful, or more so, in rapidly reducing the temperature after sunset, is the rapidity of radiation; the slightly heated earth beneath the crops will more rapidly radiate its heat than the highly heated desert, and the curve of cooling will be more abrupt in the one case than in the other. The problem of the relative amounts of reduction of temperature, due to radiation and evaporation respectively, remains to be solved. Dr. Marcet[1] has recorded some very interesting experiments on radiation in Egypt, and on the cooling of the Nile by night from these two causes, but the relative influence of the two factors remains unsettled.

The lower relative humidity of Upper Egypt and the desert, with only a slight visible screen, if any, in the air, as compared with the frequent cloudiness of Lower Egypt, allows radiation and evaporation to proceed far more rapidly, hence the effects produced by cultivation are more strongly marked in Upper Egypt, and the daily range of temperature is larger and reaches the highest recorded in the cultivated land. The rapidity of evaporation at times is so great, that a thin layer of water is frozen, when the surrounding air is several degrees above the freezing-point, and it is a common practice to cool a room rapidly as much as 10° by hanging a damp sheet before an open door or window.

Relative Humidity.

The automatic recording hair-hygrometers were made by Richard Frères of Paris, and all worked well when tested in one room in Cairo, at the commencement. The standards were Casella's dry and wet bulb thermometers. The instruments were regulated at 10 a.m. on Mondays, at all stations following the same instructions. It was found that all the instruments, in the extremes of moisture or dryness, recorded these extremes as more extensive than the percentage, as calculated from the readings of the dry and wet bulbs, the high percentages reading too high by 2 per cent to 4 per cent, and the low percentages too low by 2 per cent to 4 per cent. It was found that all the instruments recorded in the same manner. No correction has been made for this error. Between 20 per cent and 80 per cent of the readings were found to be the same or very nearly the same (within 1 per cent) as those resulting from the dry and wet bulb method of calculation. An effort was made to approach uniformity by standardising the instruments at an hour (10 a.m.) when the percentage at most stations was about 50 per cent. Compared with the thermometric records, which were rarely found to be as much as 0°·2 out, the hygrometric records cannot be regarded as absolute, but within the limits mentioned they represent a reliable basis for a comparative view of the relative humidity as exhibited at the various stations under a uniform method of observation; and it must be noted that the mean relative humidity of Egypt is about 50 per cent, so that the error occurring in readings over 80 per cent is compensated for in arriving at the mean by that in the readings below 20 per cent.

The relative humidity follows closely the inverse order to the temperature, and therefore will be found to be much lower in Upper Egypt than in Lower Egypt, remaining low at night at desert stations where the temperature is not so markedly depressed, as is the case in the cultivated land. Stations in Upper Egypt such as Luxor, not actually in the cultivated land, but surrounded with a dry town on the north side, the town itself being in the midst of a cultivated plain, are not, we have seen in discussing the temperature, affected by that cultivation, except to a small extent. On Luxor Roof only about a quarter the effect due to cultivation is observed in the night temperature; in other words, "Luxor Hotel Roof" station approached three-quarters of the way to the actual desert conditions observed near Luxor, as compared with the cultivated fields half a mile to the south.

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[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xi. p. 275.

The total number of readings, every two hours for three years, has been averaged, and the means at these hours are shown in Table IX., from which table the six comparative tables (L-Q) have been extracted.

Table (L) gives the mean relative humidity for the four months December to March for three years, at each two hours of the day.

TABLE (L).—RELATIVE HUMIDITY, DECEMBER TO MARCH, THREE YEARS.

STATION.		2 A.M.	4	6	8	10	Noon.	2 P.M.	4	6	8	10	Midn.	Mean.
		%	%	%	%	%	%	%	%	%	%	%	%	%
Luxor Roof	1893-94	65·6	69·0	72·9	65·9	48·5	38·9	33·1	33·5	42·9	50·6	54·3	59·7	52·9
	1894-95	65·1	69·2	70·4	63·5	49·2	35·2	28·9	29·6	39·7	48·6	53·2	59·7	51·0
	1895-96[1]	67·9	73·1	76·1	66·0	47·9	36·0	29·2	28·7	40·0	50·5	55·5	62·0	52·7
	Mean	66·2	70·4	73·1	65·1	48·5	36·7	30·4	30·6	40·9	49·9	54·3	60·5	52·2
Assouan	1893-94[2]	50·1	60·0	64·0	61·6	46·7	35·7	28·0	27·1	30·7	35·9	40·9	46·5	43·9
	1894-95[3]	46·7	51·9	56·1	53·6	37·4	26·1	19·5	19·5	23·0	29·0	34·9	41·2	36·5
	1895-96[4]	52·4	58·1	63·1	59·5	44·2	32·6	24·9	23·1	27·9	34·4	40·4	45·9	42·2
	Mean	49·7	56·7	61·1	58·2	42·8	31·5	24·1	23·2	27·2	33·1	38·7	44·5	40·
Change each 2 hrs. on previous Reading.	Luxor .	+5·7	+4·2	+2·7	−8·0	−16·6	−11·8	−6·3	+0·2	+10·3	+9·0	+4·4	+6·2	
	Assouan	+5·2	+7·0	+4·4	−2·9	−15·4	−11·3	−7·4	−0·9	+4·0	+5·9	+5·6	+5·[illegible]	

[1] March 1-23 only. [2] March 1-22. [3] December 17-31, March 1-25. [4] December 9-31.

The years are found to vary slightly in the mean, and it must be observed that the months of March and December are not complete in every case at Assouan, and on one occasion at Luxor. The mean on Luxor Roof for the three years was 52·2 per cent, and at Assouan 40·9 per cent. The change each two hours on the previous reading is indicated, and differs at the two stations as follows: starting from 6 a.m., when the figures were Luxor 73·1 per cent, Assouan 61·1 per cent; up to 10 a.m. Luxor dries rather more quickly than Assouan owing to the more rapid recovery at sunrise from a depressed minimum temperature at Luxor; thence to 2 p.m. the change is the same at both places; at 4 p.m. at Luxor there is a slight increase, whilst at Assouan it is still diminishing slightly; at 6 p.m. and 8 p.m. it rapidly increases at Luxor, slowly at Assouan; after midnight the increases to the maximum at 6 a.m. are larger at Assouan than at Luxor. In the type of a desert climate we shall see there is only a slight increase in the relative humidity up to midnight, and then rapid increases to the maximum at 6 a.m.

In Table (M) the relative humidity for January and February for two years are compared at the stations Helouan, Luxor, and Assouan. We find that at Helouan, as at Assouan at 8 a.m., there is not the rapid diminution of relative humidity that takes place at Luxor, for at both these stations the minimum temperature has not been depressed to the

TABLE (M).—RELATIVE HUMIDITY, JANUARY AND FEBRUARY, TWO YEARS.

TATION.	2 A.M.	4	6	8	10	Noon.	2 P.M.	4	6	8	10	Midn.	Mn.
	%	%	%	%	%	%	%	%	%	%	%	%	%
ouan 1895	64·0	66·5	68·0	65·7	49·7	38·7	33·2	34·2	40·7	46·2	54·2	59·5	51·7
1896	70·0	73·0	72·5	67·7	52·2	42·5	37·5	39·5	47·5	53·7	60·5	65·0	56·8
Mean	67·0	69·7	70·2	66·7	50·9	40·6	35·3	36·8	44·1	49·9	57·3	62·2	54·2
nge on pre- is Reading	+4·8	+2·7	+0·5	−3·5	−15·8	−10·3	−5·3	+1·5	+7·3	+5·8	+7·4	+4·9	...
or 1895	72·7	77·0	76·5	69·2	56·2	40·5	31·8	34·0	44·7	55·0	58·7	66·5	56·9
1896	71·5	78·2	80·2	71·0	52·0	39·7	33·0	32·2	44·5	55·2	60·0	66·5	56·9
Mean	72·1	77·6	78·3	70·1	54·1	40·1	32·4	33·1	44·6	55·1	59·3	66·5	56·9
nge on pre- us Reading	+5·6	+5·5	+0·7	−8·2	−16·0	−14·0	−7·7	+0·7	+11·5	+10·5	+4·2	+7·2	...
ouan 1895	47·7	53·7	58·2	55·5	39·7	27·0	18·7	19·0	22·2	28·0	34·9	41·2	37·1
1896	53·5	59·5	64·7	62·5	47·5	34·7	27·0	24·7	29·2	36·0	41·7	47·5	44·0
Mean	50·3	56·3	61·4	59·0	43·6	30·8	22·8	21·8	25·7	32·0	38·3	44·3	40·5
nge on pre- us Reading	+6·3	+6·0	+4·8	−2·4	−15·4	−12·8	−8·0	−1·0	+3·9	+6·3	+6·3	+6·0	...

same extent as at Luxor. Throughout the day till 4 p.m. the conditions are about the same at all three stations, but at 6 p.m. the increase at Luxor is more than at Helouan, and at Helouan more than at Assouan. The process is then similar (excepting 8 p.m. at Luxor) at all three stations till 2 a.m., then at 4 a.m. the increases are still large at Luxor and Assouan, but at Helouan the maximum was nearly reached at 2 a.m. At 6 a.m. a large increase is added to Assouan, 0·7 per cent to Luxor, and only 0·5 per cent to Helouan. For these two months the relative humidity at Helouan was 2·7 per cent less than Luxor, though for the four winter months it is 3·7 per cent greater at Helouan than at Luxor.

Table (N) is comparative for the months of January and February 1896, at five stations.

TABLE (N).—RELATIVE HUMIDITY, JANUARY AND FEBRUARY 1896.

STATION.	2 A.M.	4	6	8	10	Noon.	2 P.M.	4	6	8	10	Midn.	Mn.
	%	%	%	%	%	%	%	%	%	%	%	%	%
a House . .	83·2	85·7	89·2	88·2	66·7	48·5	41·7	45·7	56·7	67·2	74·7	79·0	68·9
ouan . . .	70·0	73·0	72·5	67·7	52·2	42·5	37·5	39·5	47·5	53·7	60·5	65·0	56·8
or	71·5	78·2	80·2	71·0	52·0	39·7	33·0	32·2	44·5	55·2	60·0	66·5	56·9
or Fields . .	94·7	97·2	97·0	90·7	61·0	48·5	44·0	47·5	69·0	80·7	83·2	88·7	75·2
uan . . .	53·5	59·5	64·7	62·5	47·5	34·7	27·0	24·7	29·2	36·0	41·7	47·5	44·0
ourly change at													
a House . .	+4·2	+2·5	+3·5	−1·0	−21·5	−18·2	−6·8	+4·0	+11·0	+10·5	+7·5	+4·3	...
uan . . .	+5·0	+3·0	−0·5	−4·8	−15·5	−9·7	−5·0	+2·0	+8·0	+6·2	+6·8	+4·5	...
r	+5·0	+6·7	+2·0	−9·2	−19·0	−12·3	−6·7	−0·8	+12·3	+10·7	+4·8	+6·5	...
r Fields . .	+6·0	+2·5	−0·2	−6·3	−29·7	−12·5	−4·5	+3·5	+21·5	+11·7	+2·5	+5·5	...
uan . . .	+6·0	+6·0	+4·9	−2·2	−15·0	−12·8	−7·7	−2·3	+4·5	+6·8	+5·7	+5·8	...

In addition to Helouan, Luxor, and Assouan, which have already been eferred to, we have here to consider Mena House and Luxor Fields.

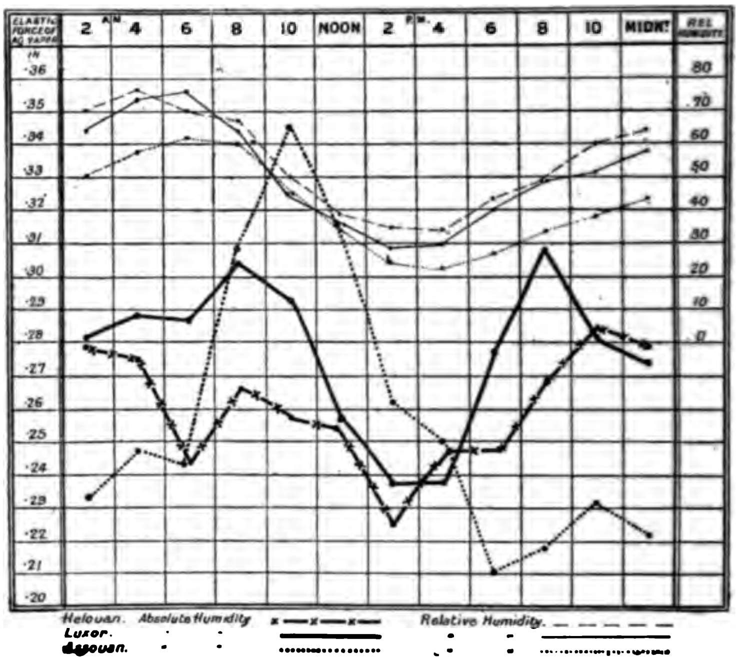

FIG. 2.—Absolute and Relative Humidity, February 1896.

At Mena House there is very little diminution of the relative humidit till 8 a.m., and at 10 a.m. it is still 14·5 per cent more than at Helouan, an 14·7 per cent more than at Luxor. At noon and at 2 p.m. the change follow in the same course as at the other stations. But at 4 p.m. at Mena Hous

TABLE (O).—LUXOR AND LUXOR DESERT WEST. THREE MONTHS, JANUARY TO MARCH 1894.

STATION.	2 A.M.	4	6	8	10	Noon.	2 P.M.	4	6	8	10	Mid
	%	%	%	%	%	%	%	%	%	%	%	%
Luxor	63·8	67·8	72·3	65·7	47·8	37·8	31·8	31·5	40·3	48·2	51·7	57
Luxor Desert[1] .	43·5	47·2	50·6	51·8	45·8	36·8	30·2	29·0	33·0	36·0	36·5	39
Change on previous Obs. Luxor.	+6·0	+4·0	+4·5	-6·6	-17·9	-10·0	-6·0	-0·3	+8·8	+7·9	+3·5	+6
Change on previous Obs. Luxor Desert.	+4·5	+3·7	+3·4	+1·2	-6·0	-9·0	-6·6	-1·2	+4·0	+3·0	+0·5	+2

[1] March 1-26.

the increase is well started, and continues in advance of Helouan till 8 p.m. The additions through the night to 6 a.m. correspond nearly to those of Helouan; at both these stations more is added before midnight than after.

At "Luxor Fields" station the additions to the relative humidity were very great at 6 p.m. (21·5 per cent) and at 8 p.m., the additions later were small, 94·7 per cent being reached at 2 a.m.

Table (O) gives the differences for the three months January to March for one year (1894) at Luxor Roof and in the Desert West of Luxor (stations: "Crest of the Libyan Hills" from January 1 to 8, and the "Valley of the Tombs of the Kings" from January 8 to March 26).

The relative humidity by night of the desert station was not much greater than that by day; it was, however, at its maximum at 8 a.m. instead of 6 a.m., as at Luxor, owing to its position in a valley with high hills to the east obstructing the sun's rays. The diminution to 10 a.m. was slight only, and the mean minimum was not reached till 4 p.m.; 6 p.m. only added 4 per cent as compared with 8·8 per cent at Luxor, and very little was added by midnight to reach only 39 per cent; after midnight more was added than before, whilst at Luxor the reverse was the case.

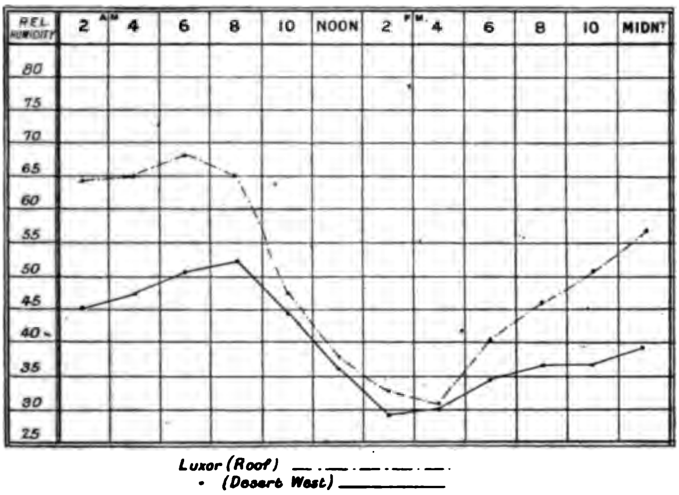

FIG. 3.—Relative Humidity, Luxor (roof) and Luxor Desert West (Valley of the Tombs of the Kings), February 1894.

Table (P) compares again Luxor Desert West [the stations being those described as (7·a) in the Nile valley, but removed from the cultivated land by 300 yards from January 1 to 12, by 2 miles from January 12 to February 11. After February 11 in the Valley of the Tombs of the Kings at the station already described as (7·β)] with Helouan, Luxor, and Assouan.

Again we find the desert has not reached its maximum till 8 a.m., but this was not the case during the time that the instruments were exposed in the Nile valley, receiving the sun's rays at sunrise, and it is therefore only a local effect in the Valley of the Tombs of the Kings. The dryness of the day is found to persist, as in the valley, to 4 p.m., and, as at that station, the increase of relative humidity is very slight up to midnight, but after midnight is more marked.

TABLE (P).—HELOUAN, LUXOR ROOF, LUXOR DESERT WEST, AND ASSOUAN, JANUAR AND FEBRUARY 1895.

STATION.		2 A.M.	4	6	8	10	Noon.	2 P.M.	4	6	8	10	dn.	Mean.
		%	%	%	%	%	%	%	%	%	%	%	%	%
Helouan . .		64·0	66·5	68·0	65·7	49·7	38·7	33·2	34·2	40·7	46·2	54·2	9·5	51·7
Luxor . . .		72·7	77·0	76·5	69·2	56·2	40·5	31·8	34·0	44·7	55·0	58·7	6·5	56
Luxor Desert W. .		51·7	57·5	63·0	62·5	49·7	37·5	29·2	28·7	34·2	36·2	39·2	4·5	44
Assouan . .		47·7	53·7	58·2	55·5	39·7	27·0	18·7	19·0	22·2	28·0	34·9	1·2	37
Change on previous Observation.	Helouan	+4·5	+2·5	+1·5	−2·3	−16·0	−11·0	−5·5	+1·0	+ 6·5	+ 5·5	+8·0	5·3	
	Luxor .	+6·2	+4·3	−0·5	−7·3	−13·0	−15·7	−8·7	+2·2	+10·7	+10·3	+3·7	+7·8	
	Luxor Desert	+7·2	+5·8	+5·5	−0·5	−12·8	−12·2	−8·3	−0·5	+ 5·5	+ 2·0	+3·0	+5·3	
	Assouan	+6·5	+6·0	+4·5	−2·7	−15·8	−12·7	−8·3	+0·3	+ 3·2	+ 5·8	+6·9	+6	

Table (Q) is only for 7 days (Jan. 1 to 7, 1894), and is comparativ of the relative humidity at the desert station (7.γ) on the "Crest of th Libyan Hills" and Luxor Roof for the same days. For the reasons mentioned in discussing the temperature, this station is more under th influence of the desert than any other in this series of observations, an therefore it will be taken as the type of the desert conditions as t

TABLE (Q).

STATION.		2 A.M	4	6	8	10	Noon	2 P.M.	4	6	8	10	Mid-night.	Mean.
		%	%	%	%	%	%	%	%	%	%	%	%	%
Crest of Libyan Hills .		48	52	55	48	46	42	39	37	42	42	42	43	45
Luxor Roof . .		73	83	85	77	55	46	40	39	52	58	65	70	62
Change on previous Observation.	"Crest"	+5	+ 4	+3	−7	− 2	−4	−3	−2	+ 5	0	0	+1	...
	"Roof"	+3	+10	+2	−8	−22	−9	−6	−1	+13	+6	+7	+5	...

relative humidity. It is also important on account of its altitude, about 300 to 350 feet. As we have shown, the effects of cultivation in reducing the night temperature and therefore increasing the relative humidity, are purely local, and on still nights do not extend to the adjacent road, so probably the increase in relative humidity over cultivated land does not extend above a few feet from the ground. In the cultivated land after sunset a thin film of mist is observed, not more than a few inches thick, over the crops, and dipping into a cultivated ditch in the same manner as a curved film. The air above this film is probably warmer than at the film, below the film it is probably cooler than at the film, but having already deposited some of its moisture, there is not sufficient remaining to form a mist below, even at the lower temperature. The elevated desert station is probably, taking into consideration the predominant North-west wind and the presence of open desert for 60 miles to the north, and for an unlimited distance to the north-west, the station the most removed from the effects of cultivation. Facing the unobstructed rising sun, it is not open to the objections that might be raised as to the station in the valley of the Kings' Tombs. The changes in this typical station are as follows:—Starting from the maximum (55) at 6 a.m., 18 per cent reduction took place by 4 p.m.; the minimum (37) being reached, 7 per cent was attained out of this 18 per cent in the first two hours by 8 a.m., a large proportion considering that at Luxor Roof 46 per cent reduction took place up to 4 p.m., of which only 8 per cent was attained by 8 a.m. The minimum was not attained till 4 p.m., which is unusual in Egypt, although the minimum may be maintained till that hour at Assouan. Out of the 18 per cent daily variation in the relative humidity, 5 per cent is attained at 6 p.m., and there is no further addition till midnight, when 1 per cent is added. After midnight 5 per cent, 4 per cent, and 3 per cent are added before 6 a.m. Thus only one-third the increase in relative humidity, from the minimum by day to the maximum at 6 a.m., is attained by midnight, and the remaining two-thirds in the six hours after midnight.

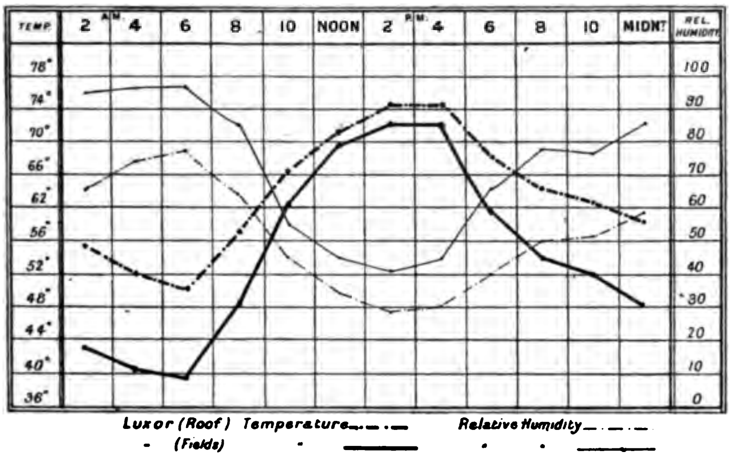

FIG. 4.—Temperature and Relative Humidity, Luxor (roof) and Luxor Fields, February 1896.

At Luxor Roof, out of a daily variation of 46 per cent, two-thirds were added before midnight, and only one-third after. We have seen that in the fields themselves the actual proportion is four-fifths before midnight and only one-fifth after. In the two cases, the "Libyan Hill Crest" and the Theban cultivated plain, we see two extremes of the conditions which vie with each other to influence the climate of Egypt, and other stations recorded in this paper will be shown to be intermediate. Hardly a station can be found in Egypt where the two influences are not commingled in varying proportions, and therefore to find comparable sites in Egypt, or to calculate the exact equivalent of local conditions, is a problem of some difficulty. If the original object of this research had been pure meteorology, perhaps more interesting results would have been obtained from desert stations on the western side, in varying latitudes sufficiently removed from the Nile valley to place them entirely under the influence of the desert with the generally prevailing North-west or North wind; but as the object was to ascertain the precise conditions under which invalids live who visit Egypt during the winter, it was necessary to select the stations at the actual places of resort. It was thought that such a research, by its general character, might in the future be of use in the selection of sites advisable as resorts, and in tending to a scientific use of the climate by artificial methods adapted to the variations found to exist.

We stated that all other stations, recorded in this series, were intermediate between the climates to be found in the cultivated Theban plain at Luxor, and the "Libyan Hill Crest" opposite Luxor. We will first take Mena House. We have seen that the proportion of relative humidity increase is in the "fields" at Luxor, four-fifths before midnight, and one-fifth after, and the proportion for the "Libyan Hill Crest" is one-third before midnight, and two-thirds after; now at Mena House for the four months, December to March 1895-96, the proportion is exactly the same as in the "Luxor Fields," that is, Mena House is as much under the influence of cultivation as the Luxor Fields. We have shown that whenever there is a moderate breeze, which is very frequent by day, Luxor Fields are certainly under the influence of the desert, whereas at Mena House, when the wind is from the North or even slightly to the West of North, which is frequently the case, the influence of the cultivated Delta is inevitably brought to bear. At night the influence of the cultivation at "Luxor Fields" is very great owing to the frequent calms, and at Mena House the same influence is strongly felt owing to the proximity (only a few yards removed) of cultivated land to the east and north. As there is no place in Egypt which is under the influence of cultivated land only, so the station "Luxor Fields," separated from unlimited desert by only two or three miles of cultivated land, is almost always by day, and frequently by night, brought under the desert influence by means of the wind, so to a similar extent is Mena House under desert influence, by means of those days and nights on which there is a breeze from the South, the West, or possibly North-west. On the nights when the wind is from North or North-north-west, and probably on calm nights on the side of the house near the cultivation, the influence of the cultivated land is marked.

Helouan and Luxor.—At both places the proportion is the same, the added relative humidity is three-quarters before midnight, and one-quarter after. The influence of cultivation at both stations is equal, and both are intermediate between Mena House and Assouan. At first sight, one would have expected Helouan, placed south of Cairo with 15 miles of desert to the north and 2 miles to the west, to be entirely under the influence of the desert, but this is not so. The question of the wind comes in, bringing the climate, and in the case of Helouan, whenever there is a wind, it is as at Mena House, mostly from the North or North-west, and passes over the cultivated Delta, or crosses the river, with its cultivation on either bank, to the west of Helouan.

At Luxor Roof we have shown that if there is calm, it is three-quarters of the way from cultivated land conditions to desert conditions. If there is a slight breeze it would be under the influence of modified cultivated land conditions; if the breeze be stronger it is under the influence of desert almost entirely. It is a question of Luxor in a small area of cultivated land and a mass of desert beyond, and Helouan in a small area of desert and receiving, by means of the wind, the effect of a mass of cultivation beyond, and the influences appear in the mean to balance each other.

Assouan approaches more nearly to the type of the "Libyan Hill Crest," being in the proportion a little more than a half before midnight, and rather more than a half after. If the station at Assouan had been on the west side of the river instead of the east, and two or three miles to the west, it would have closely approximated to the "Libyan Hill Crest." There is very little cultivation immediately to the north of Assouan, yet the prevailing wind is in the line of the river from North to South here, and although the river does not act as markedly as cultivation, it has an influence of the same kind though less in degree.

The lowest mean minimum relative humidity for any month was 13 per cent at 2 p.m. from March 1 to 22, 1894, and at 4 p.m. in March 1895, and occurred at Assouan. The lowest mean minimum for any month at Luxor was 18 per cent in March 1895 at 2 p.m. and 4 p.m.

The lowest minima of relative humidity recorded by the hair hygrometer were:—

At Assouan—

	Per Cent.
March 12, 1896, 4 p.m.	4.
Feb. 26, 1896, 2 p.m., 4 p.m., and 6 p.m.	3.
The temperatures being 102°, 96°, and 90°.	
Feb. 14, 1895, same hours	1, 0, 4.
Feb. 17, 1895, same hours	0, 0, 3.
Feb. 18, 1895, same hours	0, 0, 4.
Feb. 19, 1895, same hours and 8 p.m.	0, 0, 0, 0.
March 14, 1895, noon, 2 p.m., 4 p.m., and 6 p.m.	3, −1, −2, 0.
March 15, 1895, same hours	2, 0, −2, 5.
March 20, 1894, 2 p.m., 4 p.m., and 6 p.m.	0, 0, 3.
March 21, 1894, same hours	0, 0, 5.

Valley of the Tombs of the Kings.

March 19 and 20, 1894. The relative humidity did not exceed 27 per cent, and the minimum was 6 per cent; for the following two and a half days it did not exceed 18 per cent, and the minimum was 7 per cent. This period of five days had the lowest recorded relative humidity for a series of days. It will be observed that on two days at Assouan the recording pen actually passed below the zero of the scale.

The number of nights in the winter of 1895-96 on which the relative humidity reached 100 per cent were:—

Mena House in Dec. and Jan. 18, Feb. 22, March 24.
Luxor in Dec. 3, in Jan. 9, in Feb. 1, in March 0.
Luxor Fields in Jan. 29, in Feb. 27, in March 17 (out of 22).
Desert West of Luxor, Helouan and Assouan, 0.

The mean dew-point in Luxor Fields was in January 36°·5, in February 38°, and in March 53°. In Fig. 5 the influence of the wind in reducing the relative humidity at Luxor Fields station is shown. The force of wind and relative humidity were calculated from 5 p.m. to 5 p.m. The total miles of wind were recorded by a Robinson anemometer.[1] The relative humidity is the mean of the twelve readings of the twenty-four hours. With a rise in the force of the wind we have a fall in the relative humidity. The chart has been given to show the influence of the wind in changing the conditions due to local causes.

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[1] The anemometric figures are by the permission of Dr. Page May, for whom they were taken at Luxor.

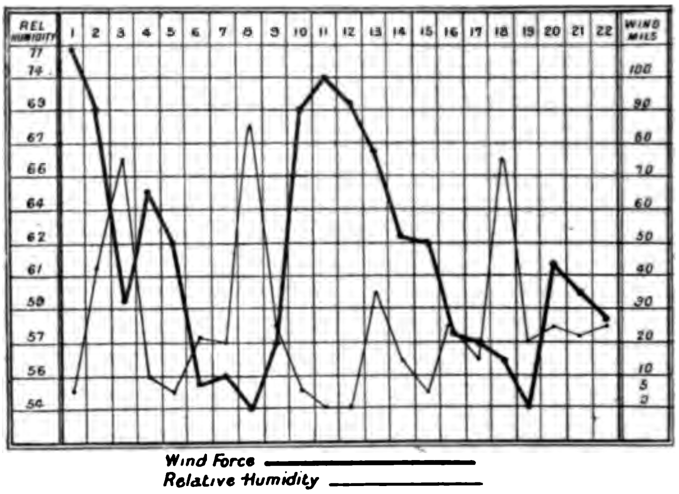

FIG. 5.—Relative Humidity and Force of Wind, Luxor Fields, March 1-22, 1896.

Absolute Humidity.

The following comparative Table (R) and Fig. 6 show the absolut amounts of humidity in the air at the four stations, Mena House, Helouan Luxor, and Assouan, taken at each two hours of the day and night for th four winter months December to March 1895-96.

TABLE (R).—MEAN ABSOLUTE HUMIDITY (GRAINS IN 10 CUBIC FEET OF AIR).

1895-96.	Mena Ho.	Helouan.	Luxor Roof.	Assouan.	Mean.
	gr.	gr.	gr.	gr.	gr.
Dec. .	39	32	33	31	34
Jan. .	32	28	31	25	29
Feb. .	34	29	30	28	30
March .	36	31	31	29	32
Mean .	35	30	31	28	31

We see that the absolute humidity varies at these stations betwe 39 grains per 10 cubic feet as a daily mean at Mena in December to at Assouan in January.

The absolute humidity (30) at Helouan is considerably less than Mena (35), and one less than at Luxor for the whole winter. Assouan it is least, being only 28.

The absolute humidity, in the mean of the four stations, is greates in December, least in January, and slowly advances in February an arch. At the individual stations this order is preserved, except at xor, where it is least in February.

Fig. 6 shows the changes each two hours at these stations for Feb- ary 1896. In this chart is included the curve for the same time of the solute humidity in the Luxor Fields. In the mean of the twelve hours the day (8 a.m. to 6 p.m.), as compared with the twelve hours of the ght (8 p.m. to 6 a.m.), Mena House, Helouan, and Luxor, are drier by y by 2 grains in the case of Mena and Helouan, and 1 grain in that of

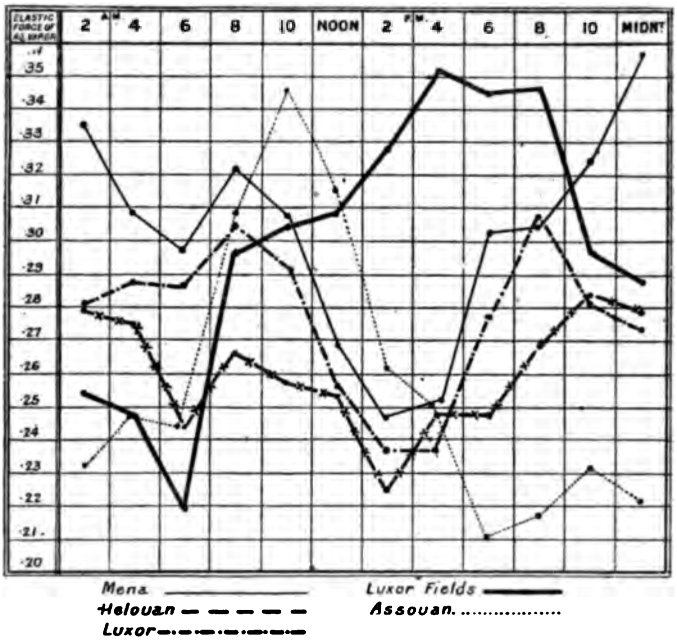

FIG. 6.—Absolute Humidity, February 1896.

xor, whereas at Assouan the air is 4 grains drier by night than by y. The curves at 8 a.m. and 10 a.m. at all the stations showed an rease of absolute humidity, this increase being occasioned by the in- ased temperature of the air enabling a greater amount of moisture to taken up. In cases where there is little if any moisture available, ring still conditions, as at Helouan and in the Valley of the Tombs of Kings (as will be seen later), the increase is, if any, very slight.

In the Luxor Fields and at Mena House, dew is taken up; the casional movements of the air from the neighbouring cultivation counting for the increase at Luxor Roof on those days on which dew s not deposited in the vicinity of the roof. At Helouan the increase least at these hours owing to the small amount of moisture available. Assouan the rising breeze up the channel of the river affords the rease exhibited, which has not passed away at noon, when the other tions are drier. During the remainder of the day till 6 p.m., the ual day breeze is able to keep the stations under desert influences, with exception of the cultivated land station, where the curve represents the mean between those days on which the wind is strong with a low relative humidity as we have shown, and those days on which the wind was slight or calm, with a high relative humidity. The mean curve resulting is decidedly in favour of the possibility of increased absolute humidity up to 4 p.m. in Luxor Fields; in other words, the days with little or no wind overbalance those with sufficient wind to bring in desert conditions. Such is the influence of cultivated land on the absolute humidity by day.

At night (6 p.m. and 8 p.m.) there is an increase of absolute humidity at Mena House, Helouan, and Luxor, commencing at 4 p.m., but being less marked at Helouan than at the other two stations; by midnight it is far greater at Mena House than at Helouan and Luxor Roof, at which stations it is about the same. At Assouan the dryness increases at 6 p.m., and it remains very dry till 2 a.m. In the Luxor Fields the absolute humidity falls after 8 p.m. when dew has probably been deposited, but at Mena House the dew-point would not be reached till after midnight as a rule. After midnight the absolute humidity falls at Mena House, Helouan, and Luxor Fields till 6 a.m., which is the hour of the minimum absolute humidity in the fields, the air being then very dry, nearly as dry as the air of Helouan at 2 p.m.

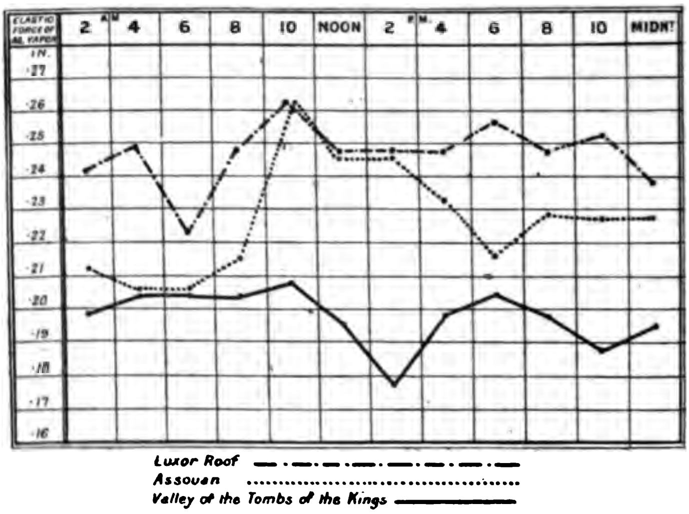

FIG. 7.—Absolute Humidity, February 13-18, 1894.

Fig. 7 shows the course of the absolute humidity in the Valley of the Tombs of the Kings, at the station described above, compared with the same 6 days on Luxor Roof and at Assouan. The air is even drier at this station through the whole twenty-four hours than at either of the other two stations, excessive dryness being attained at 2 p.m. In the previous hours of the morning, there being no moisture available, the absolute humidity remains stationary. The absence of any dew deposit in the night in the neighbourhood does not occasion any appreciable increased dryness on this account.

The mean dew-point at "Luxor Fields" was in January 36°·5, in February 38°, and in March 53°.

In February 1894, the mean dew-point at 6 a.m. in the Valley of the Tombs of the Kings was 35°, the mean temperature at that hour being 52°. At 2 p.m. in the same month the mean dew-point was at 38°·5, whilst the mean temperature was 72° or over 33° above the dew-point. At Luxor Roof the corresponding dew-points were 37°·5 and 43°·5, and at Assouan 0°·5 lower by night and 1° lower by day than at Luxor Roof.

Rain, etc.

Rain was not recorded.

The rainfall at Mena House and Helouan is less than at Cairo. At Luxor and Assouan rain is rare, and occurs to about the same extent at both stations.

At Luxor in 1893-94 it rained once in December a few drops only.

In 1894-95, it rained once in December for three-quarters of the day, not heavily. Once it rained in March a few drops only, the relative humidity being 40 per cent at the time, and a strong Khamseen wind blowing.

In 1895-96 rain fell once in February, a few drops only at 11 p.m.

Thunder was heard twice in five winters at Luxor.

TABLE I.—TEMPERATURE AT ALL STATIONS, SHOWING THE MONTHS COMPLETE AND INCOMPLETE.

STATIONS.		1893-94.						1894-95.							1895-96.						
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
		°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
CAIRO.	Min.	...	...	...	...	...	...	[3] 57·2	50·5	45·8	[4] 52·5	49·6	[5] 57·1	...	[6] 55·5	[7] 54·1	[8] 46·2	47·7	51·1	53·2	...
	Max.	...	...	...	...	...	...	73·7	69·3	68·1	77·9	73·0	86·0	...	72·6	70·8	63·7	69·5	74·6	79·9	...
	Mean.	...	...	...	...	...	...	65·4	59·9	56·9	65·2	61·3	71·5	...	64·0	62·4	55·0	58·6	62·8	66·6	...
	Range.	...	...	...	...	...	...	16·5	18·8	22·3	25·4	23·4	28·9	...	17·1	16·7	17·5	21·8	23·5	26·7	...
MENA HOUSE.	Min.	...	48·9	45·7	46·6	48·2	[2] 53·4	[9] 57·0	[10] 49·2	47·6	[11] 51·2	51·2	57·0	[12] 59·4	[13] 54·9	50·9	45·6	47·7	50·5	[14] 54·9	...
	Max.	...	68·5	65·2	69·3	72·1	77·4	75·6	67·2	71·4	77·7	75·4	84·5	85·9	71·5	69·9	63·6	68·5	73·8	79·5	...
	Mean.	...	58·7	55·4	57·9	60·1	65·4	66·3	58·2	59·5	64·5	63·3	70·8	72·6	63·2	60·4	54·6	58·1	62·1	67·2	...
	Range.	...	19·6	19·5	22·7	23·9	24·0	18·6	18·0	23·8	26·5	24·2	27·5	26·5	16·6	19·0	18·0	20·8	23·3	24·6	...
HELOUAN.	Min.	...	...	...	...	...	...	[15] 55·7	48·8	46·0	51·1	51·7	[16] 60·2	...	57·2	50·8	45·7	49·1	52·0	58·1	[17] 66·3
	Max.	...	...	...	...	...	...	75·7	69·7	70·3	77·2	77·6	88·5	...	76·9	70·5	64·0	69·8	74·9	82·9	94·3
	Mean.	...	...	...	...	...	...	65·7	59·2	58·1	64·1	64·6	74·3	...	67·0	60·6	54·8	59·5	63·4	70·5	80·3
	Range.	...	...	...	...	...	...	20·0	20·9	24·3	26·1	25·9	28·3	...	19·7	19·7	18·3	20·7	22·9	24·8	28·0
LUXOR (ROOF).	Min.	[18] 55·3	49·4	44·2	47·8	55·2	60·9	...	48·4	47·4	49·1	55·2	...	...	...	49·9	45·5	49·2	[19] 54·4	...	...
	Max.	88·0	75·4	73·4	76·0	84·7	89·8	...	75·5	77·3	82·2	86·4	...	...	...	76·3	70·2	75·8	83·8	...	...
	Mean.	71·6	62·4	58·8	61·9	69·9	75·3	...	61·9	62·3	65·6	70·8	...	...	...	63·1	57·9	62·5	69·1	...	...
	Range.	32·7	26·0	29·2	28·2	29·5	28·9	...	27·1	29·9	33·1	31·2	...	...	...	26·4	24·7	26·6	29·4	...	...
LUXOR DESERT W.[1] OR LUXOR FIELDS.	Min.	...	...	50·1	[20] 52·5	[21] 61·3	...	...	50·3	49·9	[22] 56·8	...	...	...	...	...	35·9	37·5	[23] 44·5	...	...
	Max.	...	...	65·1	71·8	83·0	...	...	75·3	76·9	82·1	...	...	...	...	...	67·9	73·7	82·5	...	...
	Mean.	...	...	57·6	62·1	72·1	...	...	62·8	63·4	69·4	...	...	...	...	...	51·9	55·6	63·5	...	...
	Range.	...	...	15·0	19·3	21·7	...	...	25·0	27·0	25·3	...	...	...	...	...	32·0	36·2	38·0	...	...
ASSOUAN.	Min.	...	54·0	[24] 49·4	51·1	[25] 54·2	...	[26] 55·3	51·7	53·0	56·2	61·0	...	...	[27] 58·5	54·0	48·6	52·1	60·7	...	...
	Max.	...	75·3	73·8	75·8	84·9	...	79·5	77·7	80·5	88·1	91·1	...	...	86·4	81·1	75·3	81·1	90·4	...	...
	Mean.	...	64·6	61·6	63·4	69·5	...	67·4	64·7	66·7	72·1	76·0	...	...	72·4	67·5	62·0	66·6	75·6	...	...
	Range.	...	21·3	24·4	24·7	30·7	...	24·2	26·0	27·5	31·9	30·1	...	...	27·9	27·1	26·7	29·0	29·7	...	...

[1] 1893-94. Valley of the Tombs of the Kings. 1894-95. Dec. 3, 1894, to Jan. 11, 1895, 300 yards in the Desert W. of Luxor. Jan. 12, 1895, to Feb. 11, 1895, 1½ miles in the Desert W. of Luxor. 1896. Luxor Fields.

[2] 5th to 15th.

[3] 10th to 30th.

[4] 18th to 24th missing.

[5] to 21st.

[6] 13th to 30th.

[7] 1st to 10th.

[8] 7th to 28th.

[9] 10th to 30th.

[10] 18th to 31st.

[11] 10th to 12th and 23rd to 25th missing (4 days).

[12] 1st to 12th.

[13] 20th to 30th.

[14] 1st to 18th.

[15] 10th to 30th.

[16] 25th to 28th missing.

[17] 1st to 11th.

[18] 22nd to 30th.

[19] to 22nd.

[20] to 22nd.

[21] 1-5 and 26-31 missing.

[22] 16-24 missing.

[23] March 1-3, 10 and 11, 17-23.

[24] 22-29 missing.

[25] to 22nd.

[26] 25-30.

[27] ? reliable.

TABLE II.—MEAN TWO-HOURLY TEMPERATURES, 1895 TO 1896.

Hour.	Cairo.					Mena House.						Helouan.						Luxor (Roof).					Luxor Fields.				Assouan.				
	Dec.[1]	Jan.[2]	Feb.[3]	Mar.	Mean.	Dec.	Jan.	Feb.	Mar.	Apr.[4]	Mean (a)	Dec.	Jan.	Feb.	Mar.	Apr.	Mean (a)	Dec.	Jan.	Feb.	Mar.[5]	Mean.	Jan.	Feb.	Mar.[6]	Mean.	Dec.	Jan.	Feb.	Mar.	Mean.
2 A.M.	58·0°	49·0°	50·5°	55·0°	53·1°	55·0°	50·5°	52·0°	54·5°	59·5°	53·0°	54·5°	49·5°	53·5°	56·5°	63·0°	53·5°	55·5°	50·5°	55·0°	61·5°	55·6°	41·0°	43·0°	53·5°	45·8°	58·0°	52·5°	56·5°	66·0°	58·0°
4	57·5	47·5	49·0	53·5	51·9	53·5	48·5	50·5	53·0	57·5	51·4	52·5	48·0	51·5	55·0	60·5	51·7	52·5	48·5	52·0	59·0	53·0	39·0	41·0	53·0	44·3	56·0	50·5	54·0	63·0	55·9
6	56·0	46·5	48·5	51·5	50·6	52·5	47·0	49·5	51·5	56·5	50·1	52·0	47·0	50·5	53·0	59·0	50·6	51·0	47·0	50·5	57·0	51·0	37·5	39·5	54·5	43·8	54·5	49·0	52·5	62·0	54·0
8	55·5	47·0	50·5	54·5	51·9	53·5	48·0	51·5	56·0	63·0	52·2	55·0	49·5	52·0	58·0	65·0	53·6	56·5	50·5	57·5	65·0	57·4	42·0	49·0	70·0	53·7	60·0	54·5	59·0	70·0	60·9
10	62·0	53·0	59·5	63·5	59·5	60·0	55·0	59·5	65·0	70·5	59·9	62·5	56·0	60·5	66·5	73·5	61·4	66·0	59·5	66·5	73·5	66·4	56·0	62·5	76·5	65·0	70·0	64·5	70·0	80·5	71·2
Noon	69·0	59·0	66·0	70·5	66·1	66·0	60·5	65·5	70·0	76·5	65·5	67·5	61·0	66·0	71·5	79·0	66·5	71·5	65·5	71·5	79·5	72·0	63·0	69·5	83·5	72·0	77·0	71·5	77·0	86·5	78·0
2 P.M.	72·5	62·0	68·0	73·0	68·9	68·5	62·5	67·5	72·5	78·5	67·7	69·5	63·0	68·5	73·5	81·5	68·6	75·0	68·5	74·5	82·5	75·2	66·5	72·5	85·0	74·7	80·0	74·0	80·0	88·5	80·6
4	70·0	60·0	65·5	72·0	66·9	66·5	60·5	66·5	71·5	77·5	66·2	67·5	61·5	68·0	72·5	81·0	67·4	75·0	68·5	74·5	82·5	75·2	66·0	72·0	84·0	74·0	77·5	72·5	78·0	86·0	78·5
6	65·0	57·0	61·0	68·0	62·7	62·5	57·5	62·0	67·0	73·5	62·2	62·5	57·5	64·0	68·5	77·0	63·1	68·5	62·5	68·5	76·5	69·0	56·5	61·5	71·5	63·2	71·0	65·0	71·5	79·0	71·6
8	62·0	54·5	57·5	63·0	59·2	60·0	55·0	57·5	62·5	67·0	58·7	59·5	55·0	60·5	64·0	72·0	59·7	64·5	59·0	64·5	71·5	64·8	50·0	54·5	66·5	57·0	66·5	61·5	67·0	75·0	66·0
10	60·5	52·0	54·0	59·5	56·5	57·5	53·0	55·5	59·0	63·5	56·2	58·0	53·0	57·5	61·0	68·0	57·4	60·0	56·5	62·5	67·5	61·6	46·5	52·0	62·5	53·7	63·0	57·5	64·0	71·5	64·0
12	59·5	50·5	52·0	57·0	54·7	55·5	51·5	53·5	56·5	61·0	54·2	56·0	51·0	55·5	58·5	65·5	55·2	57·0	53·0	58·5	64·5	58·2	43·5	48·0	56·0	49·2	60·0	54·5	60·5	68·0	60·7
Mean	62·3	53·2	56·8	61·8	58·5	59·2	54·1	57·6	61·6	67·0	58·1	59·7	54·3	59·0	63·2	70·4	59·0	62·7	57·4	63·0	70·0	63·3	50·6	55·4	68·0	58·0	66·0	60·6	65·3	74·7	66·6

[1] December 1-9. [2] January 6-27. [3] February 3-29. [4] April 1-18. [5] March 1-23. [6] March 17-23. (a) Excluding April.

TABLE III.—Temperature. Mean of Four Months, 1895 to 1896.

Station.	Month.	Min.	Max.	Mean.	Range.
Mena House	December	50·9°	69·9°	60·4°	19·0°
	January	45·6	63·6	54·6	18·0
	February	47·7	68·5	58·1	20·8
	March	50·5	73·8	62·1	23·3
	Mean	48·7	68·9	58·8	20·3
Helouan	December	50·8	70·5	60·6	19·7
	January	45·7	64·0	54·8	18·3
	February	49·1	69·8	59·5	20·7
	March	52·0	74·9	63·4	22·9
	Mean	49·4	69·8	59·6	20·4
Luxor (Roof)	December	49·9	76·3	63·1	26·4
	January	45·5	70·2	57·9	24·7
	February	49·2	75·8	62·5	26·6
	March	54·4	83·8	69·1	29·4
	Mean	49·7	76·5	63·1	26·8
Assouan	December	54·0	81·1	67·5	27·1
	January	48·6	75·3	62·0	26·7
	February	52·1	81·1	66·6	29·0
	March	60·7	90·4	75·6	29·7
	Mean	53·8	82·0	67·9	28·1

TABLE IV.—Temperature. Mean of Four Months for Two Years.

Station.	Month and Year.	Min.	Max.	Mean.	Range.
Helouan	December 1894	48·8°	69·7°	59·2°	20·9°
	,, 1895	50·8	70·5	60·6	19·7
	January 1895	46·0	70·3	58·1	24·3
	,, 1896	45·7	64·0	54·8	18·3
	February 1895	51·1	77·2	64·1	26·1
	,, 1896	49·1	69·8	59·5	20·7
	March 1895	51·7	77·6	64·6	25·9
	,, 1896	52·0	74·9	63·4	22·9
	Mean	49·4	71·7	60·5	22·3
Luxor (Roof)	December 1894	48·4	75·5	61·9	27·1
	,, 1895	49·9	76·3	63·1	26·4
	January 1895	47·4	77·3	62·3	29·9
	,, 1896	45·5	70·2	57·9	24·7
	February 1895	49·1	82·2	65·6	33·1
	,, 1896	49·2	75·8	62·5	26·6
	March 1895	55·2	86·4	70·8	31·2
	,, 1896	54·4	83·8	69·1	29·4
	Mean	49·9	78·4	64·1	28·5
Assouan	December 1894	51·7	77·7	64·7	26·0
	,, 1895	54·0	81·1	67·5	27·1
	January 1895	53·0	80·5	66·7	27·5
	,, 1896	48·6	75·3	62·0	26·7
	February 1895	56·2	88·1	72·1	31·9
	,, 1896	52·1	81·1	66·6	29·0
	March 1895	61·0	91·1	76·0	30·1
	,, 1896	60·7	90·4	75·6	29·7
	Mean	54·7	83·2	68·9	28·5

TABLE V.—TEMPERATURE. MENA HOUSE. JANUARY, FEBRUARY, MARCH AND APRIL FOR THREE YEARS; DECEMBER FOR TWO YEARS.

MONTH AND YEAR.	Min.	Max.	Mean.	Range.
December 1893 . . .	48·9°	68·5°	58·7°	19·6°
,, 1895 . . .	50·9	69·9	60·4	19·0
Mean . .	49·9	69·2	59·5	19·3
January 1894 . . .	45·7	65·2	55·4	19·5
,, 1895 . . .	47·6	71·4	59·5	23·8
,, 1896 . . .	45·6	63·6	54·6	18·0
Mean . .	46·3	66·7	56·5	20·4
February 1894 . . .	46·6	69·3	57·9	22·7
,, 1895 . . .	51·2	77·7	64·5	26·5
,, 1896 . . .	47·7	68·5	58·1	20·8
Mean . .	48·5	71·8	60·2	23·3
March 1894 . . .	48·2	72·1	60·1	23·9
,, 1895 . . .	51·2	75·4	63·3	24·2
,, 1896 . . .	50·5	73·8	62·1	23·3
Mean . .	50·0	73·8	61·8	23·8
April 1894[1] . . .	53·4	77·4	65·4	24·0
,, 1895 . . .	57·0	84·5	70·8	27·5
,, 1896[2] . . .	54·9	79·5	67·2	24·6
Mean . .	55·1	80·5	67·8	25·4
Mean of all .	50·0	72·4	61·2	22·4

[1] April 5-15.

[2] April 1-18.

TABLE VI.—TEMPERATURE. LUXOR ROOF. THREE YEARS.

MONTH AND YEAR.	Min.	Max.	Mean.	Range.
December 1893 . . .	49·4°	75·4°	62·4°	26·0°
,, 1894 . . .	48·4	75·5	61·9	27·1
,, 1895 . . .	49·9	76·3	63·1	26·4
Mean . .	49·2	75·7	62·4	26·5
January 1894 . . .	44·2	73·4	58·8	29·2
,, 1895 . . .	47·4	77·3	62·3	29·9
,, 1896 . . .	45·5	70·2	57·9	24·7
Mean . .	45·7	73·6	59·7	27·9
February 1894 . . .	47·8	76·0	61·9	28·2
,, 1895 . . .	49·1	82·2	65·6	33·1
,, 1896 . . .	49·2	75·8	62·5	26·6
Mean . .	48·7	78·0	63·3	29·3
March 1894 . . .	55·2	84·7	69·9	29·5
,, 1895 . . .	55·2	86·4	70·8	31·2
,, 1896 . . .	54·4	83·8	69·1	29·4
Mean . .	54·9	85·0	69·9	30·0
Mean of all .	49·6	78·1	63·8	28·4

TABLE VII.—TEMPERATURE. ASSOUAN. DECEMBER AND FEBRUARY FOR THREE YEARS; JANUARY AND MARCH FOR TWO YEARS.

MONTH AND YEAR.	Min.	Max.	Mean.	Range.
	°	°	°	°
December 1893	54·0	75·3	64·6	21·3
,, 1894	51·7	77·7	64·7	26·0
,, 1895	54·0	81·1	67·5	27·1
Mean . .	53·2	78·0	65·6	24·8
January 1895	53·0	80·5	66·7	27·5
,, 1896	48·6	75·3	62·0	26·7
Mean . .	50·8	77·9	64·3	27·1
February 1894	51·1	75·8	63·4	24·7
,, 1895	56·2	88·1	72·1	31·9
,, 1896	52·1	81·1	66·6	29·0
Mean . .	53·1	81·7	67·4	28·5
March 1895	61·0	91·1	76·0	30·1
,, 1896	60·7	90·4	75·6	29·7
Mean . .	60·8	90·7	75·8	29·9
Mean of all .	54·5	82·1	68·3	27·6

TABLE VIII.—TEMPERATURES. MONTHLY EXTREMES AND RANGE.

STATION.	Year.	Extremes.		Range.	Daily Means.		Range.	Daily Range.		STATION.	Year.	Extremes.		Range.	Daily Means.		Range.	Daily Range.	
		Min.	Max.		Highest.	Lowest.		Greatest.	Least.			Min.	Max.		Highest.	Lowest.		Greatest.	Least.
Mena House.	Dec. 1893	38°	86°	48°	71°	52°	19°	32°	4°	Mena House.	Feb. 1894	40°	77°	37°	64°	54°	10°	32°	11°
	1894	...	...	...	...	...	...	...	...		1895	44	99	55	82	56	26	36	17
	1895	45	77	32	70	54	16	27	13		1896	38	92	54	73	50	23	40	9
	Mean	41·5	81·5	40	70·5	53	17·5	29	8		Mean	40·6	89	48·4	73	53	20	36	12
Helouan.	1893	...	...	...	...	...	...	...	...	Helouan.	1894	...	...	...	...	...	...	...	...
	1894	41	84	43	70	51	19	27	12		1895	45	97	52	82	56	26	35	14
	1895	42	80	38	67	54	13	26	4		1896	42	92	50	75	50	25	39	10
	Mean	41·5	82	40·5	69	53	16	26	8		Mean	43·5	94·5	51	78	53	25	37	12
Luxor.	1893	39	89	50	73	53	20	35	11	Luxor.	1894	40	90	50	69	57	12	42	12
	1894	40	85	45	70	55	15	34	9		1895	43	99	56	78	59	19	42	18
	1895	42	86	44	71	55	16	32	11		1896	42	96	54	78	54	24	41	12
	Mean	40	86·6	46·6	71	54	17	34	10		Mean	41·6	95	53·4	75	57	18	42	14
Assouan.	1893	41	90	49	76	52	24	29	9	Assouan.	1894	45	90	45	72	57	15	40	9
	1894	41	88	47	74	54	20	33	13		1895	50	103	53	83	62	21	44	18
	1895	48	92	44	76	60	16	36	15		1896	43	103	60	85	56	29	42	14
	Mean	43	90	47	75	55	20	33	12		Mean	46	99	53	80	58	22	42	14
Mena House.	Jan. 1894	39	79	40	69	51	18	26	8	Mena House.	Mar. 1894	42	92	50	70	51	19	41	15
	1895	37	82	45	69	50	19	36	13		1895	43	91	48	77	55	22	38	8
	1896	37	74	37	64	48	16	24	4		1896	45	88	43	73	56	17	33	13
	Mean	37·6	78	40·4	67	49	18	29	8		Mean	43·3	90·3	47	73	54	19	37	12
Helouan.	1894	...	...	...	...	...	...	...	...	Helouan.	1894	...	...	...	...	...	...	...	...
	1895	37	81	44	67	50	17	34	12		1895	44	92	48	76	55	21	39	12
	1896	39	72	33	65	50	15	27	10		1896	47	87	40	70	59	11	34	11
	Mean	38	76·5	38·5	66	50	16	30	11		Mean	45·5	89·5	44	73	57	16	36	11·5
Luxor.	1894	38	86	48	70	54	16	43	19	Luxor.	1894	42	104	62	84	55	29	44	13
	1895	37	89	52	72	53	19	37	10		1895	45	102	57	87	61	26	47	12
	1896	38	82	44	67	53	14	33	9		1896	48	(101)[1] 93	?45	89	63	26	40	16
	Mean	37·6	85·6	48	70	53	17	38	13		Mean	45	103	58	87	60	27	44	14
Assouan.	1894	41	88	47	72	53	19	35	10	Assouan.	1894	43	109	66	86	57	29	46	14
	1895	44	89	45	74	59	15	39	8		1895	53	108	55	92	66	26	47	9
	1896	43	91	48	73	56	17	35	7		1896	54	105	51	93	68	25	42	16
	Mean	42·6	89	46·4	73	56	17	36	8		Mean	50	107	57	90	64	26	45	13

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[1] 101 would be the interpolated figure missing, on the day of a high Temperature at Assouan.

TABLE IX.—RELATIVE HUMIDITY, 1893-1896.

Hour.	1 Luxor Roof, 1893-94.					2 Luxor Desert W., 1893-94.				3 Assouan, 1893-94.					4 Helouan, 1894-95.					5 Luxor Roof, 1894-95.					6 Luxor Desert W., 1894-95.				
	Dec.	Jan.	Feb.	Mar.	Mean.	Jan.	Feb.[1]	Mar.[2]	Mean.	Dec.	Jan.	Feb.	Mar.[3]	Mean.	Dec.	Jan.	Feb.	Mar.	Mean.	Dec.	Jan.	Feb.	Mar.	Mean.	Dec.[4]	Jan.	Feb.	Mar.[5]	Mean.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
2 A.M.	71	73·5	64·5	53·5	65·6	52	45	33·5	43·5	53·5	56	50·5	40·5	50·1	74	63·5	64·5	68·5	67·6	67·5	71·5	74	47·5	65·1	71·5	56·5	46·5	31·5	51·5
4	72·5	81	65	57·5	69	57	47·5	37	47·2	70	65	55	50	60	76	65·5	67·5	73	70·5	71·5	76·5	77·5	51·5	69·2	75·5	64·5	50·5	35	56·4
6	74·5	86	68	63	72·9	61·5	51	39·5	50·6	73	70·5	57·5	55	64	77	66·5	69·5	74	71·7	73·5	78·5	74·5	55	70·4	80·5	70·5	55·5	39	61·4
8	66·5	77·5	65	54·5	65·9	62·5	52	41	51·8	68	73	59	46·5	61·6	68	65·5	66	62	65·4	66·5	70·5	68	49	63·5	77	66·5	58·5	41·5	60·9
10	50·5	58	47·5	38	48·5	58·5	44·5	34·5	45·8	54	55·5	46	31·5	46·7	59	50	49·5	45·5	51	49·5	54	58·5	35	49·2	56	51·5	48	35·5	47·7
Noon	42	46	38	29·5	38·9	49	36	25·5	36·8	43·5	42	37·5	20	35·7	50·5	39·5	38	37	41·2	38·5	41	40	21·5	35·2	42·5	38	37	24	35·4
2 P.M.	37	39·5	32·5	23·5	33·1	41·5	29·5	19·5	30·2	37·5	31·5	30	13	28	45	34	32·5	33	36·1	33	33·5	31	18	28·9	34·5	28	30·5	17·5	27·6
4	39·5	40·5	31·5	22·5	33·5	39	30·5	17·5	29	39	28	28	13·5	27·1	47·5	35	33·5	32·5	37·1	32·5	34	34	18	29·6	32	27·5	30	15·5	26·2
6	50·5	52	40·5	28·5	42·9	43·5	34·5	21	33	44·5	30·5	31	17	30·7	56·5	40·5	41	39·5	44·4	45	46	43·5	24·5	39·7	40	35	33·5	18·5	31·7
8	58	59	46·5	39	50·6	45·5	36·5	26	36	49·5	37	36	21	35·9	60	46·5	46	49	50·4	54·5	56	54	30	48·6	45	37·5	35	21·5	34·7
10	62	64	50·5	40·5	54·3	45·5	36·5	27·5	36·5	54	43	40	26·5	40·9	65	55	53·5	58	57·9	60·5	59	58·5	35	53·2	54	42·5	36	24	39·1
12	65·5	70·5	57	46	59·7	48·5	39	29·5	39	58·5	49	46	32·5	46·5	68	60	59	64	62·7	65·5	65·5	67·5	40·5	59·7	62·5	49·5	39·5	27·5	44·7
Mean	57·5	62·3	50·5	41·3	52·9	50·3	40	29·3	39·9	53·7	48·4	43	30·6	43·9	62·2	51·8	51·7	53	54·7	54·8	57·2	56·7	35·5	51	55·9	47·3	41·7	27·6	43·1

[1] Feb. 1-22 and 28. [2] Mar. 1-26. [3] Mar. 1-22. [4] Dec. 3-31. [5] Mar. 1-14.

Hour	7 Assouan, 1894-95.					8 Mena House. 1895-96.					9 Helouan, 1895-96.					10 Luxor Roof, 1895-96.					11 Luxor Fields, 1895-96.				12 Assouan, 1895-96.				
	Dec.[6]	Jan.	Feb.	Mar.[7]	Mean.	Dec.	Jan.	Feb.	Mar.	Mean.	Dec.	Jan.	Feb.	Mar.	Mean.	Dec.	Jan.	Feb.	Mar.[8]	Mean.	Jan.	Feb.	Mar.[9]	Mean.	Dec.[10]	Jan.	Feb.	Mar.[11]	Mean.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
2 A.M.	56	54·5	41	35·5	46·7	83·5	80	86·5	85·5	83·9	69·5	70	70	69·5	69·7	73·5	78·5	64·5	55	67·9	95	94·5	87	92·2	60·5	56·5	50·5	42	52·4
4	59·5	61	46·5	40·5	51·9	87	86	85·5	87·5	86·5	72·5	72·5	73·5	73	72·9	77	83	73·5	59	73·1	98	96·5	91	95·2	66	61·5	57·5	47·5	58·1
6	62	65·5	51	46	56·1	89·5	91	87·5	91·5	89·9	73·5	75	70	76	73·5	78	84·5	76	66	76·1	98	96	95·5	96·5	70·5	67	62·5	52·5	63·1
8	59·5	60·5	50·5	44	53·6	88	90·5	86	86	87·6	70·5	67·5	68	68	68·5	65·5	78·5	63·5	56·5	66	96	85·5	79	86·8	65·5	64	61	47·5	59·5
10	38·5	43	36·5	31·5	37·4	75·5	72	61·5	60	67·2	60	54·5	50	47·5	53	48	58·5	45·5	39·5	47·9	66·5	55·5	48	56·6	47·5	48·5	46·5	34·5	44·2
Noon	30	31	23	20·5	26·1	57	54·5	42·5	42·5	49·1	46	46	39	35·5	41·5	36·5	44·5	34	29	36	53	44	38	45	37	35·5	34	24	32·6
2 P.M.	26	23·5	14	14·5	19·5	47·5	45·5	38	34·5	41·2	39·5	41	34	28·5	35·7	29	36·5	29·5	22	29·2	46·5	41·5	29·5	39·2	28	28·5	25·5	17·5	24·9
4	27	24·5	13·5	13	19·5	51·5	50·5	41	37	45	40·5	45·5	33·5	29·5	37·2	29·5	34·5	30	21	28·7	49·5	45·5	29·5	42·8	25·5	26·5	23	17·5	23·1
6	32	27·5	17	15·5	23	65	59·5	54	47	56·2	51·5	52·5	42·5	37·5	46	43·5	49	40	27·5	40	72·5	65·5	42·5	60·2	32	31·5	27	21	27·9
8	40	33·5	22·5	20	29	73	67	67·5	59·5	66·7	57	58	49·5	45·5	52·5	55·5	60·5	50	36·5	50·5	84	77·5	61·5	74	38·5	38·5	33·5	27	34·4
10	46·5	41·5	27·5	24	34·9	79	72	77·5	74·5	75·7	65	61	60	56·5	61·2	61	68·5	51·5	41·5	55·5	90·5	76	65	77·2	46	45·5	38	32	40·4
12	52·5	48	34·5	30	41·2	82	76	82	81	80·2	67	66·5	63·5	62·5	64·7	67·5	75	58	47	62	92·5	85	74·5	84	52	51·5	43·5	36·5	45·9

DISCUSSION.

The President (Mr. E. Mawley) said that the thanks of the Society were due to Dr. Canney for his paper, and the author was sorry that he was not able to be present to read it himself. He hoped, however, that Dr. Marcet, whom he was glad to see among them again, would offer some observations upon it.

Dr. W. Marcet said that he had listened with much interest to the paper, and thought it useful, and well deserving the attention of the Society. He regretted that rainfall was so slightly mentioned. Dr. Canney had also omitted to refer to solar radiation, which was a great pity, for in such dry climates extraordinary sun temperatures were generally to be looked for. Whilst staying on the Peak of Teneriffe, he (Dr. Marcet) had experienced great heat from the sun's rays, and Mr. Piazzi Smyth had reported a temperature of 212°·4 estimated from the readings of a solar radiation thermometer. Dr. Canney might have been able to give us an idea of the heat our soldiers had been subject to during the recent campaign, had he included these observations in his paper. The radiation taking place at sunset was interesting. He himself, when at Luxor, had experienced no appreciable chill at sunset, but only some hours later. He had noticed the curious fact that at about one hour after sunset the temperature would undergo a slight temporary *rise*, as if a mass of heat, or heat vibrations caused by radiation, affected the thermometers. The sensation of chill at, or after sunset, occurred much sooner at Cairo than at Luxor. Dust storms were a peculiar feature of Egypt. It is impossible for any one to realise or understand their nature except by experience. At times they are almost suffocating in their intensity.

Dr. C. Theodore Williams remarked that he took a great interest in the paper, especially as it was at his suggestion that the author had undertaken the observations. There was plenty of data available for Cairo and its neighbourhood, but little was known of more Southern Egypt, especially of the climate of the desert. Dr. Canney's observations were not complete, being only for the winter months, and for a short period ; but for the first time the meteorology of the desert proper is placed before us. The temperature charts exhibited were remarkably similar in character, showing a regular increase and decrease of heat day after day, the minimum being reached about 4 a.m. and the maximum at 2 p.m. As with Dr. Marcet he had noticed no appreciable chilling of the atmosphere at sunset. When the temperature fell 1° F. the mean range was 3°·0 to 3°·4. The results from those stations situated in or near the desert were most interesting, and plainly showed the differences of climate between the cultivated lands and the desert. It was noticeable that the extremes were much smaller in the desert. The roof position for the instruments was the most satisfactory, as the gardens were flooded by the Nile, the water even occasionally rising to the first floor of the hotel. With regard to the extremely low humidities by day he (Dr. Williams) was not so much astonished at those as at the high ones at night. Generally in the early morn the trees and plants were dripping with moisture, while in the day everything was as dry as a bone. It was surprising to him where the moisture came from. Many curious effects were noticed from the dust storms, the landscape often seeming to fade away and the sun to turn green. A rise of temperature generally followed a dust storm. He believed that Dr. Canney had made some observations on solar radiation, but they were few, and being made at only one or two stations, were not comparable. With regard to rainfall Upper Egypt is remarkably free from it, and in some parts the people are so certain of none falling that they build houses chiefly of mud, which would certainly disappear were a heavy shower to fall. Dr. Canney was deserving of great praise for his admirable paper, and for the labour and expense he had gone to to increase our information.

The only objection Dr. Williams had to the winter climate of the Nile was the cold North wind, felt on descending the river, and this was hardly to be experienced in the sheltered villages; but, naturally, the decks of steamers were fully exposed to it. The dry, clear atmosphere accounted for the air being completely aseptic, for carcases in the desert do not putrefy, but simply dry up into a mummy condition; and also for the wonderful preservation of the monuments and of wall-paintings 3000 years old.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 20, 1897.

Ordinary Meeting.

Edward Mawley, F.R.H.S., President, in the Chair.

Hubert Airy, M.A., M.D., Stoke House, Woodbridge;
Carsten Egeberg Borchgrevink, 22 Akersveien, Christiania;
Thomas Lawrence Fearon, 27 Guildhall Street, Folkestone;
Henry Lowenfeld, F.R.G.S., 21 Lowndes Square, S.W.;
Charles Frederick Marston, Assoc.M.Inst.C.E., Linthorpe, Sutton Coldfield;
Edward Picton Phillips, M.R.C.S., Cloghan House, Haverfordwest;
William Henry Symons, M.D., D.P.H., Guildhall, Bath; and
David Thomas Williams, Post Office, Blaeaclydach, Llwynypia, R.S.O.,
were balloted for and duly elected Fellows of the Society.

January 20, 1897.

Annual General Meeting.

Edward Mawley, F.R.H.S., President, in the Chair.

Mr. J. Hopkinson and Mr. J. G. Wood were appointed Scrutineers of the Ballot for Officers and Council.

Mr. F. C. Bayard read the Report of the Council and the Balance-Sheet for 1896 (p. 87).

It was proposed by the President, seconded by Mr. F. C. Bayard, and resolved:—"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal.*"

It was proposed by Mr. M. Jackson, seconded by Mr. W. B. Tripp, and resolved:—"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year."

It was proposed by Mr. F. J. Brodie, seconded by Mr. W. M. Beaufort, and resolved:—"That the thanks of the Society be given to the Standing Committees and to the Auditors, and that the Committees be requested to continue their duties till the next Council meeting."

It was proposed by Mr. A. Brewin, seconded by Dr. C. T. Williams, and resolved:—"That the most cordial thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its meetings in the rooms of the Institution."

The PRESIDENT then delivered an address on "SHADE TEMPERATURE" (p. 69).

It was proposed by Mr. H. S. EATON, seconded by Mr. B. LATHAM, and resolved :—"That the thanks of the Society be given to Mr. EDWARD MAWLEY for his services as President during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal*."

The Scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year :—

PRESIDENT.

EDWARD MAWLEY, F.R.H.S.

VICE-PRESIDENTS.

GEORGE CHATTERTON, M.A., M.Inst.C.E.
WILLIAM HENRY DINES, B.A.
WILLIAM ELLIS, F.R.S., F.R.A.S.
RICHARD INWARDS, F.R.A.S.

TREASURER.

HENRY PERIGAL, F.R.A.S., F.R.M.S.

SECRETARIES.

FRANCIS CAMPBELL BAYARD, LL.M.
GEORGE JAMES SYMONS, F.R.S.

FOREIGN SECRETARY.

ROBERT HENRY SCOTT, M.A., F.R.S.

COUNCIL.

ROBERT BARNES, M.D., F.R.C.P.
FREDERICK JOHN BRODIE.
Capt. ALFRED CARPENTER, R.N., D.S.O., F.Z.S.
RICHARD HENRY CURTIS.
HENRY NEWTON DICKSON, F.R.S.E.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
Rear-Admiral JOHN PEARSE MACLEAR, R.N., F.R.G.S.
HUGH ROBERT MILL, D.Sc., F.R.S.E., F.R.G.S.
HENRY SOUTHALL, F.R.H.S.
HERBERT SOWERBY WALLIS.
CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.
Capt. DAVID WILSON-BARKER, F.R.S.E., F.R.G.S.

February 17, 1897.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

CHARLES VINCENT BELLAMY, Assoc.M.Inst.C.E., Dominica, West Indies ; and
JOHN PALMER DALTON, Moorfield, Ryton-on-Tyne,
were balloted for and duly elected Fellows of the Society.

The following communications were read :—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1896." By EDWA MAWLEY, F.R.H.S., President (p. 119).

"RESULTS OF OBSERVATIONS ON HAZE AND TRANSPARENCY NEAR HASLEMERE, SURREY." By the Hon. F. A. ROLLO RUSSELL, M.A., F.R.Met.Soc. (p. 145).

CORRESPONDENCE AND NOTES.

Parhelia, January 29, 1897.—On this day beautifully bright parhelia were observed over the northern part of England.

Mr. H. Mellish, of Hodsock Priory, Worksop, says: "The morning was a fine one with bands of cirrus. Between noon and 1 p.m. when the halo was seen there was an extremely delicate cirrus veil. Two bright parhelia were formed on the 22° circle (coloured), and a very bright contact arc of rather a sharp curvature touching the 46° circle, also a very faint one touching the 22° circle. Both of these were coloured and were above the sun. No part of the circles concentric with the sun were seen. Later the cirrus veil became denser, and the above were replaced by the ordinary 22° circle: by 3 p.m. the sun was altogether obscured and the afternoon was a dark one."

Mr. S. R. Lewis, of the Bradford Corporation Waterworks at Bolton Abbey, states that one of the foremen told him "that between noon and 1 p.m. he happened to be looking at the sun, which was then shining brightly, and saw two 'mock suns,' one on either side of the actual sun, and above them was an inverted bow—that is, a bow with its convex side turned to the sun. After this had remained in evidence for some considerable time it faded away, and was replaced by a large complete circle with the sun as its centre."

Mr. J. W. Scholes of Grimscar, Huddersfield, observed a coloured solar halo with two "mock suns," and also a "semi-inverted rainbow" (*sic*). [The "rainbow" was a coloured semi-circle.—ED.]

Discussion of Cloud Observations.—Observations on the movements and heights of clouds have, for some years past, been systematically carried on at the Blue Hill Observatory, Mass., under the direction of Mr. A. L. Rotch. An elaborate discussion of these observations has been made by Mr. H. H. Clayton, and published in the *Annals of the Astronomical Observatory at Harvard College* (vol. xxx. part iv.). In observing the movements of the clouds, they were separated into five levels, viz. the *Stratus* level, mean altitudes, 508 metres (1667 feet); the *Cumulus* level, 1614 metres (5295 feet); the *Alto-Cumulus* level, 3856 metres (12,651 feet); the *Cirro-Cumulus* level, 6633 metres (21,761 feet); and the *Cirrus* level, 8884 metres (29,148 feet). The mean altitudes given after each name are taken from the theodolite measurements made at the Observatory in 1890-91. If the middle points between these means be taken as the limits of each level, more than 80 per cent of all the clouds recorded in each level are found with these limits. The directions of motion of the clouds were observed with a nephoscope devised by Mr. H. H. Clayton and are recorded in degrees of azimuth, beginning with the south as zero and running through west (90°) to north (180°).

Probably the most important conclusion derived from the discussion of these observations is that the cyclonic and anticyclonic systems of circulation observed at the earth's surface are but secondary phenomena in the atmospheric circulation. Their control of the air movements ceases to be apparent above an altitude of

1500 or 2000 metres (about a mile). Above that they can be distinguished only as residuals after the general atmospheric drift has been eliminated. Above 2000 metres, the atmospheric circulation is primarily controlled by the permanent temperature gradient between equator and pole, by the seasonal temperature gradient between ocean and continent, and by the temporary and progressive differences of temperature over large areas called in the United States "warm" and "cold waves." That this is true also for Germany seems highly probable from the close agreement of the results at Blue Hill with those found at Berlin by Dr. Vettin, when the two are treated in the same way. On the other hand, the results of Ley and Hildebrandsson indicate that the cyclonic circulation extends to greater heights and exerts a greater control over the atmosphere, as a whole, in Northern Europe, than is the case farther south. This is no doubt due to the weak temperature gradients in that region.

In regard to the origin of cyclones and anticyclones, Dr. Hann's studies of the mountain observations so strongly oppose the convectional theory, that it seems difficult to avoid the conclusion that the cyclones and anticyclones are driven circulations whose energy is derived from the larger atmospheric movements. However, the indraught found at the top of the anticyclone, and especially the indications of a cyclonic whirl shown by the diagrams, seem to prove an inward gradient above; that is, a lower pressure above the centre of the anticyclone than in the surrounding air at the same level, a condition opposed to the theory of the driven anticyclone as stated by Dr. Hann. The larger atmospheric circulations of "warm" and "cold waves," which are here found to override the circulations of cyclones and anticyclones, are no doubt more permanent than the latter; and it is quite probable that the improvement of weather forecasts for a day or two in advance lies in the observation and study of these larger air movements by means of clouds, balloons, kites, and mountain observatories.

Simultaneous Balloon Ascensions.—On November 14, 1896, a series of simultaneous balloon ascensions were made in various parts of Europe under the auspices of the recent International Meteorological Conference. Seven balloons were sent up, each carrying a set of self-recording instruments. The greatest heights attained and the lowest temperatures recorded were as follows:—

Place.	Height. ft.	Lowest Temperature. °
St. Petersburg . . .	16,400	−11·2
Warsaw	6,560	− 4·0
Berlin	19,680	−14·1
Do.	18,540	−11·9
Strasburg	25,260	−22·0
Paris	49,210	−76·0
Munich	11,480	+20·3

The above observations represent the conditions prevailing in the midst of a large area of high pressure, that was moving slowly eastward over Europe.

Reduction of Greenwich Meteorological Observations.—Part iii. of the above gives the results of a discussion of the observations of the temperature of air at the Royal Observatory, Greenwich, during the fifty years, 1841-90. Full tables show the mean, the maximum, the minimum, and the daily range of temperature for each day during the whole period. These are succeeded by other tables giving means, extremes, etc., from which the following particulars have been extracted:—

The earliest date in any year on which the maximum temperature of the year occurred, was May 6, in 1862, when 81°·5 was registered, and the latest date was August 21, in 1883, with 85°·5. The highest temperature recorded during the fifty years was 97°·1 on July 15, 1881. In 1860 the temperature never rose above 76°·5.

The latest date in spring on which the minimum temperature of the year occurred was March 26, in 1850, when 20°·0 was registered, and the earliest date in autumn was November 24, in 1858, with 20°·5. The lowest temperature recorded was 4°·0 on January 9, 1841. In 1863 the temperature never fell below 26°·5. The number of days on which the temperature fell to or below the freezing-point varied from 17 in 1872 to 95 in 1879. The latest date in spring on which a temperature of or below 32° was registered was May 24, [illegible] 1867, and the earliest date in autumn was September 27, in 1885.

During the period 1841-90, there were 140 days on which the temperature fell to or below 20°; of these 106 were between 15° and 20°, 26 between 10° and 15°, 7 between 5° and 10°, and 1 only below 5°. On January 8, 18[illegible] the maximum temperature did not exceed 16°·7.

The temperature rose to 90° or above on two days in succession on J[illegible] 4–5; and July 31–August 1, 1846; July 12–13, 1859; July 4–5, 188[illegible] July 3–4, 1887; and on three days in succession on July 20–22, 1868; and August 13–15, 1876.

RECENT PUBLICATIONS.

Annales de l'Observatoire Météorologique du Mont Blanc. Publiées sur la direction de J. VALLOT. Tome II. 4to. 1896. 280 pp.

This volume commences with some photographic views of the interior of the Mont Blanc Observatory, showing the various rooms, consisting of a kitchen, a workshop, a study, and a snug parlour for the director. There are also views of the exterior of the observatory and of the cabin or refuge on the "Bosses" rocks. M. Vallot then gives his second series of observations taken simultaneously at three stations, one at the summit of Mont Blanc, another at the Grands Mulets, and the third at Chamonix; the altitudes being respectively 4357, 3020, and 1085 metres (or 14,295, 9908, and 3560 feet). The barometric observations extend over three years—1890, 1891, and 1892. M. Vallot will give the hygrometric and thermal observations in a volume which he hopes to publish this year. Then follows a memoir on the diurnal variation of pressure on the summit of Mont Blanc by M. P. du Boys. This is a discussion of some of the results given in vol. i. After this are the actinometric observations made by Mons. J. Vallot and Madame Gabrielle Vallot during the solar eclipse of June 17, 1890. Then comes an exhaustive memoir by M. Vallot on solar actinometry. He made use of the mercurial actinometer of Crova, an instrument which he says has the advantage of giving a definite value in a few minutes, so that it lends itself to even hourly observations; besides this it is not necessary in this instrument, as it is in that of Violle, to make use of ice, which is difficult to obtain at the lower station, as well as being inconvenient to handle. But (M. Vallot observes) although the Crova instrument is a little complicated in construction yet he can vouch, after careful observation, that the results given by its use at different stations are absolutely comparable. M. Vallot's observations result in the value 1700 = A, the solar constant. There is also an essay on the difficulties of scientific observations at great altitudes, and several papers on the petrology and the mensuration of the mountains.

M. Vallot generously places his observatory at the disposal of students of all nations, and he specially hopes to see some Fellow of the Royal Meteorological Society make use of the building.

Annuaire de la Société Météorologique de France. Janvier — Mars. 1896. 4to.

Contains :—Marées : par M. Hauvel (4 pp.).—Nébulosité suivant la hauteur u baromètre : par P. Cœurdevache (1 p.). The author has discussed the ecords from the Perpignan Observatory, and in this paper gives the mean mount of cloud according to the height of the barometer. The results are ummarised in the following table :—

Height of Barometer.	Observations.	Amount of Cloud.	State of Sky.	
			Fine to Cloudy.	Very cloudy to Overcast.
mm.			%	%
740	3·4	9·0	5	95
745	18·2	8·8	15	85
750	72·3	8·1	28	72
755	198·0	7·3	44	56
760	438·6	5·6	58	42
765	209·3	4·0	77	23
770	53·5	2·6	83	17
775	6·1	2·7	90	10
780	0·6	0·8	100	0

L'orage du 24 Décembre 1895 : par F. Tardy (3 pp.).

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. December 1896—March 1897. 4to.

The principal articles are :—Ueber die Durchsichtigkeit hörerer Luftchichten nach den Beobachtungen der Alpenaussicht am südlichen Schwarz wald : von Dr. Schultheiss (10 pp.). From all the hills in the Black Forest there s visible in clear weather a magnificent Alpine panorama, extending from Mont Blanc to the Ortler Spitz. At the meteorological station at Höchenschwand, t the level of over 3000 feet, the number of times this view is visible has been ecorded for many years past. The observations for the 12 years 1883-94 have een carried out by one man ; and for this period there are on the average 94 ays per year on which the Alps could be seen, and 11 days per year on which he view was specially clear. By far the majority of the days of visibility ccurred with anticyclonic weather, and they were mainly confined to the winter eason. The visibility is generally observed for more than one day, and on one ccasion it lasted for 14 successive days (December 28, 1889, to January 10, 890). The visibility is not very closely related to the action of rain in learing the air, and it is distinctly proved that an excessive degree of visibility does not precede rain. Dr. Schultheiss also investigated the visibility on working days and holy days, and found that smoke from the lowland towns was not perceptible in its influence on the clearness of the air at the level of 3000 eet. It is mainly the action of the descending currents in anticyclones which rings about the absence of dust in the atmosphere.—Wiener Bodentemperauren in den Jahren 1878 bis 1894 : von Dr. A. Tilp (6 pp.). This is a discussion of the observations on earth temperatures made at five different depths, viz. 0·37, 0·58, 0·87, 1·31, and 1·82 metres. The method was that roposed by Ebermayer, of attaching the thermometers in a glass envelope to a od which is lowered into a wooden tube, closed with wood above and with metal below. The results are worth study for those interested in the subject.—Meteorologische Beobachtungen in Norwegen während der Sonnenfinsterniss am August 1896 : von Prof. H. Mohn (8 pp.). Dr. Mohn organised a regular ystem of observations during the late solar eclipse, and he combined with these he observations made by Dr. H. R. Mill, Rev. J. C. Mitchell, and Mr. H. W. Blake, F.R.S. The results as to temperature were that within the zone of otality there was a depression of from 1°·8 to 2°·5 at stations where the sky was overcast. At three stations where the sun shone the depression was greater. At stations in the northern zone the depression was far less, the mean never exceeding 0°·5. There was hardly any definite effect to be detected in the barograms.—Böen und Tornados: von M. E. Durand-Gréville (14 pp.). The author seeks to show that squalls and tornados of more or less intensity occur in all cyclonic storms, and that if a line of observing stations were maintained along the Pacific coasts of the United States the advent of these tornados could be foreseen, and the necessary warnings issued.—Ein neuer registrirender Regenmesser: von Dr. G. Hellmann (4 pp.). Dr. Hellmann has devised a new self-recording rain gauge, made by Fuess, of Berlin, at the very low cost of 150 marks (£7 : 10s.), the papers costing 5 marks per 100. The receiver has a float which rises as rain falls in, until the siphon empties the receiver, so that the registration is upwards, not downwards as in the Beckley gauge. There is no recourse to electricity, and the whole apparatus is to be taken indoors in winter. —Ueber einen Satz der Thermometrie: von Dr. J. Hartmann (6 pp.). This is an inquiry into a deduction from Newton's law of cooling, which, as the author says, has not yet met with sufficient notice; that is, that the sensibility of a thermometer (*i.e.* the rapidity with which it shows changes of temperature) should be determined specially. The author took an earth thermometer from its position underground, and brought it into a warm room, and then took its readings every minute for an hour, when the temperature became constant. The author points out the importance of this inquiry in questions of the accordance between standard readings and thermograph curves.—Die vertikale Komponente der ablenkenden Kraft der Erd-rotation und ihre bewegenden Wirkungen: von Dr. A. Sprung (11 pp.). This is a somewhat controversial paper, in which Dr. Sprung proceeds to prove that the views of Dr. Ekholm and others as to the influence of the vertical component are not well founded.—Ueber das Verhältniss des Cyklonenkranzes der Hochdruckgebiete zu den Tiefdruck-Isobaren: von Baron G. von Friesenhof (10 pp.). The author has for many years past issued forecasts for his agricultural neighbours in the valley of the Neutra in Western Hungary. In this paper he points out the importance of the anticyclones on the motion of the cyclones. He takes the area which embraces Europe, in fact the northern half of a map of the eastern hemisphere in any atlas. In this he assumes four or five great anticyclones, and as many cyclones, and he seeks to show that out of their configurations he can foretell the weather for Hungary. The plates to illustrate the paper appeared with the part for April.

Symons's Monthly Meteorological Magazine. January—March 1897. 8vo.

The principal articles are:—The Earthquake of December 17, 1896 (8 pp.). This earthquake, which occurred at 5.32 a.m., affected an area of about 350 miles in diameter. Structural damage was experienced in the valley of the Severn, the centre of the earthquake being in the neighbourhood of Hereford.—Water at unusually low temperatures (5 pp.). This is an account of some experimental observations made with wet-bulb thermometers during the frost on November 30, 1896. Although the temperature fell to 25°·4 the muslin and cotton of one of the thermometers did not freeze, while those on another thermometer were completely frozen.—A tornado at Este's Park, Colorado (1 p.).—Sunshine at Kimberley, South Africa: by J. R. Sutton (4 pp.).—The temperature of February 1897 (3 pp.).—The gale of March 3, 1897 (2 pp.).

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METEOROLOGICAL INSTRUMENTS IN 1837 AND IN 1897.

By G. J. SYMONS, F.R.S., SECRETARY.

A Lecture delivered before the Royal Meteorological Society, March 17, 1897.
(Plates II.-IV.)

THERE is something rather oppressive in feeling that one occupies a position absolutely without precedent, and not likely to be similarly occupied for centuries to come. That is my case. The Council of the Royal Meteorological Society, like all Her Majesty's loyal subjects, wished to do something to celebrate the sixtieth year of her beneficent reign. The Council thought that an illustrative exhibition of the meteorological appliances of 1837 and 1897 would appropriately show the progress made since Her Majesty ascended the throne; and having decided upon holding such an Exhibition to commemorate the unique occasion, they honoured me with a request to address you to-night.

Before saying anything respecting meteorology, I hope that it will not be thought inappropriate if I express my conviction that the personal goodness and prudence of Her Majesty the Queen have been of priceless service to the nation, and that it would indeed have been well for Britain if all her subjects had tried as hard to be good, and to do their duty, as our Sovereign has done.

At the opening of a lecture somewhat analogous to this, Prof. Ayrton has recently remarked upon the difficulty of summarising the work of 60 years in 60 minutes, and I think that it is well to call attention to the impossibility, for the same reason, of adequately discharging the task which I have undertaken. Evidently no time must be spent over preliminaries, and I must try to give a description of meteorological instruments available in 1837, and in 1897, rather than to trace step by step the progress from the one to the other. Papers read before this Society have given the chronological history of most meteorological instruments; and it might be thought that, by merely sorting out those invented prior to 1837, we should at once have a statement of what wer in use at that date;—but that is quite wrong. It is one thing to describ an instrument, another to have it made, and quite another to ensure it being generally employed. It may be as well to illustrate this by som facts. The dry and the wet bulb thermometers, used synchronously as hygrometer, were employed by Prof. Boeckmann of Carlsruhe in th summer of 1802; they were again used (probably re-invented) by the Rev Mr. Gordon of Kinfauns, Perth, in 1817; and after another 19 year namely in 1836, they were again brought out as a novelty by Mr. J. A. Mason They were then taken up by the opticians, and a very early specime (given to me by Admiral FitzRoy) is in the Exhibition. Yet—and thi is the point to which I have to call attention—I am not at all sure tha at one single station a dry and wet bulb hygrometer was in regular us in 1837. Therefore the mere dates of inventions will not help us i determining the usual instrumental equipment of a meteorological statio in 1837. Consequently, in order to ascertain what were the instrument supplied by the best makers for use at well-equipped stations in 1837 we must look elsewhere.

As regards what may be described as theoretical meteorology, we hav in the splendid reports prepared for the British Association and publishe in 1832 and 1840, and in Mahlmann's German edition of the earlier, survey by Prof. J. Forbes of the state of knowledge of meteorology abou 1837, absolutely unequalled and unapproachable. But these throw onl side-lights on the question before us—What were the appliances in use i 1837?

For more than half of the sixty years with which we have to deal, have not merely been collecting records of rainfall for the current year but have been searching for old records; and thus I have graduall accumulated returns for byegone years, far more numerous than thos known to any one living at that time. For, it must not be forgotten that in 1837, postage, printing, and intercourse generally, were very differen from what they are now.

It occurred to me that if I compiled a list of all the observers wh were at work in 1837, it would bring to my mind many facts which without that guidance, I might not think of; and then the further ide arose, that it would be very little more trouble to tabulate the rainfal for the year, and so finally, as a sort of contribution to the records of th Diamond Jubilee, I have prepared a *British Rainfall* 1837 (pp. 207-210 which by and by can be compared with *British Rainfall* 1897.

I am not going to weary you by reading it, but I may mention tha it contains perfect records from the following number of stations:—

England	Wales	Scotland	Ireland	Total
91	5	60	5	161

Moreover, there are incomplete records from 19 other stations.

COUNTY.	STATION.	OBSERVER.	Height of Gauge.			Rain in 1837.
			Above Ground.		Above Sea.	
	ENGLAND.		ft.	in.	ft.	in.
llesex	Sunbury	Rev. J. Cowe	...		...	20·84
,	Chiswick	Roy. Hort. Soc.	1	0	30	19·88
,	London, Somerset Ho.	Roy. Soc.	...		150	17·93
,	Tottenham	Luke Howard	...		...	20·61
,	Edmonton	C. H. Adams	...		...	18·86
ey	Cobham Lodge	Miss Molesworth	1	0	100	18·53
	Wickham	R. L. Hinds	...		...	24·93
	Greenwich, Blackheath Road	J. H. Belville	...		...	22·94
	,, Royal Obs.	Astronomer-Royal	...		...	21·00
ex	Chichester, W. Dean	Rev. G. H. Woods	0	9	250	27·57
	,, Chilgrove	W. L. Woods	0	6	284	27·01
	Petworth	— Sockett	...		180	17·45
ts	Gosport	J. H. Maverley	...		...	22·59
s	Sandhurst	Roy. Mil. Coll.	4	8	246	17·06
	Reading, Athenæum	The Curator	...		150	21·41
s	Hemelhemstead, Nash Mills	J. Dickinson	3	0	250	21·10
s	High Wycomb	S. L. Kent	...		250	23·71
	Aylesbury, Hartwell	Dr. Lee	...		...	22·81
rd	Oxford, Radcliffe Obs.	The Observer	22	0	234	19·35
hampton	Towcester, Blakesley	Rev. F. H. White	...		...	22·74
	Wellingborough	...	...		...	23·81
ord	Bedford	...	...		...	26·51
	,, Observatory	Admiral Smyth	...		120	25·07
bridge	Swaffham Bulbeck	Rev. L. Jenyns	0	4	...	19·67
k	Southend, South chur.	C. Parsons	...		...	23·79
	Stratford	Luke Howard	0	3	...	21·13
	Epping	T. Squire	6	0	360	19·92
lk	Eye, Thwaite	O. Whistlecraft	2	8	117	22·74
olk	Norwich, Grey Friars	W. Brooke	0	0	50	24·93
	Salisbury, Baverstock	Rev. W. E. Hony	3	0	339	29·19
et	Gillingham	T. Thompson	1	5	110	25·94
n	Plympton St. Mary, Goodamoor	H. H. Treby	0	2	580	36·40
	Tavistock	T. Windeatt	...		...	46·60
	Exeter, St. Thomas	The Medical Officer	3	0	50	27·63
	,, Institution	The Secretary	13	7	155	23·70
	Honiton, Broadhembury	Rev. W. Heberden	2	4	600	28·39
wall	Falmouth	Lovell Squire	5	6	120	35·30
	Wadebridge, St. Breocke	Rev. Sir H. Molesworth, Bart.	...		...	33·91
rset	Watchet, Kilton	J. Govett	...		...	20·43
	Bath, Swainwick	Rev. F. Lockey	30	0	...	24·24
cester	Cheltenham, High St.	S. Moss	5	0	200?	27·87
ford	Hereford, Pool Cott.	J. Pendergrass	1	0	450	30·14
	,,	H. Lawson	...		...	26·21
	Shifnall Vicarage	Rev. J. Brooke	4	6	400	25·57
	Cleobury Mortimer, Mawley Hall	W. Hunter	...		600	31·18
	Oswestry, Whittington	Rev. C. A. A. Lloyd	...		...	26·50
ester	Worcester	...	...		...	24·46
	Tenbury, Orleton	T. H. Davis	0	9	209	28·55
vick	Birmingham, Phil. Inst.	Dr. Ick	...		490	27·24
ster	Leicester, London Rd.	T. Burgess	0	0	...	26·56
nd	Empingham	W. Fancourt	4	0	220?	22·37

County.	Station.	Observer.	Height of Gauge. Above Ground.		Height of Gauge. Above Sea.	Rain in 1837.
			ft.	in.	ft.	in.
Lincoln	Bourne, Wytham on the Hill	Gen. Johnson	4	3	167	21·5
,,	Spalding, Pode Hole	A. Harrison	0	11	19	23·9
,,	Boston	W. Veall	...		40	23·5
,,	Sleaford	Rev. H. Neucatre	1	0	46	19·0
Derby	Derby	— Stone	...		...	27·8
Cheshire	Hyde	T. Ashton	...		320	34·9
Lancashire	Liverpool, Percy St.	A. Abraham	...		...	30·1
,,	,, W. Derby	G. Cooke	0	6	...	32·33
,,	Manchester, Ardwick Green	L. Bucham	..		...	35·6
,,	,,	Dr. Dalton	...		...	33·1
,,	,, Market St.	J. Casartelli	20	0	...	29·9
,,	Oldham, Royton	J. Heap	24	0	500	31·0
,,	Rochdale, Slattocks	Rochdale Canal Co.	20	0	450	26·7
,,	Bolton le Moors	H. H. Watson	2	3	320	42·2
,,	Bury	Rochdale Canal Co.	0	6	313	44·0
,,	Rochdale, Moss Lock	,, ,,	20	0	510	27·8
,,	,, Castle Hill	— Ecroyd	0	4	500	45·3
,,	Blackstone Edge Res.	Rochdale Canal Co.	20	0	1225	38·1
,,	Hawkhead, Esthwaite	T. A. Beck	...		215	69·1
,,	Monk Coniston	J. G. Marshall	4	11	150	64·9
York W. R.	Sheffield, Redmires	Sheffield W. W. Co.	5	0	1100	38·6
,,	Pontefract, Ackworth	The Scholars	...		135	25·3
,,	Ripponden	Rochdale Canal Co.	20	0	...	33·6
,,	Blackstone Edge Toll Bar	,, ,,	20	0	1000	34·1
,,	Wakefield, Heath	Rev. R. Drake	20	0?	...	19·1
,,	Sowerby Bridge	Rochdale Canal Co.	20	0	268	26·5
,,	Ferrybridge, Homefield	C. Charnock	...		30	25·2
,,	Halifax, Wellhead	J. Waterhouse	1	0	540	34·8
,,	Sowerby B., Stubbins	Rochdale Canal Co.	20	0	364	32·3
,,	Leeds, Philos. Hall	The Secretary	40	0	137	13·9
,,	York, Bootham	J. Ford	...		50	23·9
,,	Settle	J. Tatham	35	0	498	44·1
York E. R.	Beverley, Middleton	Rev. — Blanchard	1	0	156	24·1
York N. R.	Scarb'ro', Belle Vue	P. Hawkridge	...		170	25·1
Durham	Bishopwearmouth	Dr. H. Ogden	30	0	130	20·05
Northumberland	Allenheads	Rev. W. Walton	2	0	1400	51·47
Cumberland	Whitehaven	Dr. Miller	...		90	45·33
,,	Ullswater, Hallstead	J. G. Marshall	4	0	497	53·20
,,	Penrith	— Bird	...		...	35·54
,,	,, Crewgarth	— Hunsonby	...		...	26·94
,,	Wigton Hall	...	...		...	37·33
,,	Carlisle	Dr. Elliot	...		...	32·61
Westmoreland	Kendal	S. Marshall	4	6	149	48·39
,,	Patterdale Hall	J. G. Marshall	4	0	490	75·10

WALES.

County.	Station.	Observer.	Height of Gauge. Above Ground.		Height of Gauge. Above Sea.	Rain in 1837.
Glamorgan	Cardiff, Fairwater	E. David	...		...	55·15
,,	Swansea	J. W. G. Gutch	40	0	52	28·47
Carnarvon	Bangor	J. Wyatt	3	0	25	39·87
Isle of Man	Calf of Man	Board of N. Lights	...		...	23·09
,,	Point of Ayre	,, ,,	...		...	27·65

COUNTY.	STATION.	OBSERVER.	Height of Gauge.		Rain in 1837.
			Above Ground.	Above Sea.	
	SCOTLAND.		ft. in.	ft.	in.
Wigtown	Mull of Galloway	Board of N. Lights	...	...	23·25
,,	Stranraer, Castle Kennedy	The Earl of Stair	...	...	36·76
,,	Corsewall	Board of N. Lights	3 4	22?	31·78
Kirkcudbright	St. Mary's Isle	...	20 0	...	37·63
,,	Kells, Kenmure Cas.	...	...	...	52·25
Dumfries	Applegarth Manse	Rev. W. Dunbar	...	...	35·20
Roxburgh	Kelso, Makerstoun	Sir T. Brisbane, Bt.	18 0	192	22·02
,,	,, ,,	,, ,,	6 6	171	26·96
Berwick	Duns, Abbey St. Bathans	Rev. J. Wallace	...	450	31·82
Haddington	Haddington	T. Dodds	...	...	24·60
,,	Smeaton	...	...	...	25·64
Edinburgh	Pentland Hills, Crawley Cottage	Edinb. W. W. Co.	...	...	41·62
,,	Musselburgh, Inveresk	Sir D. Milne	...	70	27·41
,,	Edinburgh, Canaan Cottage	A. Adie	...	...	26·77
Lanark	Glasgow, Observatory	Dr. Cowper	20 0	80	26·63
Ayr	Kilmarnock, Lanfine	...	...	...	47·38
,,	Paisley, Back Thornley Muir	...	...	693	56·65
Renfrew	Glasgow, Langside	...	...	...	36·75
,,	Paisley, Nethercraigs	...	...	160	52·50
,,	Greenock, Shaw's Waterworks	...	...	...	55·22
,,	,, Infirmary	...	...	120	32·39
,,	,, ,, Garden	...	...	...	49·15
,,	,, Fox Street	...	...	...	46·50
Stirling	Strathblane, Carbeth	W. Smith	...	470	43·16
,,	Drymen	Rev. A. Lochore	...	...	42·50
Bute	Pladda	Board of N. Lights	...	130	42·46
,,	Rothesay Mills	— Thom	...	10	45·20
Argyleshire	Castle Toward [Rothesay]	J. Finlay	...	...	44·90
,,	Lochgilphead, Ballimore	...	...	...	46·70
,,	,, Kilmory Ho.	...	50 0	170	51·88
,,	Mull of Kintyre	Board of N. Lights	...	279?	36·91
,,	Rhinns of Islay	,, ,,	3 0	74?	32·93
,,	Lismore	,, ,,	3 4	37?	34·25
,,	Mull, Achnacroish	...	...	...	67·00
Clackmannan	Dollar	T. Gibson	4 0	178	43·79
Fifeshire	Inchkeith	Board of N. Lights	...	...	24·71
,,	Dunfermline	Rev. H. Fergus	...	...	27·70
,,	Pittenweem	D. Tennant	3 0	75	16·41
,,	Isle of May	Board of N. Lights	...	...	18·22
Perthshire	Doune, Deanston	J. Smith	2 0	80	36·90
,,	Kinfauns Castle	Earl Gray	...	20	27·80
,,	,, ,, Tower	,,	...	180	27·49
,,	Methven, Busby	D. Wyley	30 0?	...	28·22
,,	Stanley	Rev. W. Mather	2 0	200	29·77
Forfar	Dundee, Tay Bank	...	...	50	26·07
,,	,, Manse	...	...	450	27·00
,,	,, Hillhead	Dundee Water Co.	...	500	26·80
,,	,, Seichen	...	...	500	30·35

COUNTY.	STATION.	OBSERVER.	Height of Gauge.		F
			Above Ground.	Above Sea.	1
			ft. in.	ft.	
Forfar . . .	Dundee, Burnhead .	...	...	...	2
,, . . .	Forfar, Glamis .	...	...	...	3
Kincardine . .	Banchory House .	...	...	...	2
Aberdeen . .	Aberdeen . .	G. Innes . .	...	60	2
,, . .	Alford . . .	Rev. J. Farquharson	...	420	3
,, . .	Buchanness . .	Board of N. Lights	...	...	2
,, . .	Kinnaird's Head .	,, ,,	...	...	1
Banffshire . .	Gordon Castle. .	The Duke of Richmond	...	110	1
Elgin . . .	Elgin, Anderson's Inst.	— Allan . .	7 0	...	2
Ross . . .	Tarbetness . .	Board of N. Lights	3 4	61 ?	2
Inverness . .	Barrahead . .	,, ,,	3 0	640 ?	3
,, . .	Harris, Island Glass .	,, ,,	...	...	2
Sutherland . .	Cape Wrath . .	,, ,,	3 6	355	2
Caithness . .	Dunnethead . .	,, ,,	3 0	...	2
,, . .	Pentland Skerries .	,, ,,	3 3	72 ?	2
Orkney . .	Sanda, Start Point .	,, ,,	0 6	29 ?	2
Shetland . .	Sumburgh Head	,, ,,	...	...	1
	IRELAND.				
Cork . . .	Cork, Royal Inst. .	The Curator .	...	50 ?	2
Dublin . .	Dublin, Phœnix Park	Roy. Engineers .	8 0	167	2
Sligo . . .	Collooney, Markree Observatory	E. J. Cooper .	16 0	145	4
Antrim . .	Belfast, Linen Hall.	The Librarian .	4 0	12	2
Tyrone . .	Cookstown, Tullyhogue	T. Dickson . .	...	...	4

As already explained, the primary object of compiling this list wa inform myself respecting the stations actually at work in 1837— more than half of them may be dismissed at once as merely rai stations, at which no records of barometer, thermometer, hygrometer anemometer were made. Although only three of the observers are living, I have, in bygone years, had the pleasure of visiting and know many—perhaps half—of them, and of seeing their instruments *in* Moreover, some information can be gleaned from books and papers Daniell, Howard, Lubbock, and others. It is from these sources co tively that I intend to describe the *ordinary outfit* of a meteorolog station in 1837. It will be well to explain why I used the w "ordinary outfit." Perhaps an actual case will illustrate best wh mean. Mr. Ellis, in the excellent *History of the Barometer*, which prepared for this Society in 1886, dated the Fortin cistern back 1810 (?). Prof. Forbes, in his report, published in 1832, tells us Dr. Prout, F.R.S. (author of one of the Bridgwater Treatises) had su barometer,[1] but no results from it are known to me—nor do I kno any observer who was using that pattern in 1837. As my object i describe the instruments in use by good, ordinary observers in 183 intend to mention those which I know to have been in use, and whic believe, any one going to the shops of the opticians of that day—New of Regent St., Jones of Oxenden St., Cary of the Strand, Potter of the Poultry, Long of Martin's Lane, or Harris of Holborn—would have obtained at once.

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[1] My impression is that the point was not ivory, but agate.

Barometer.—There were three patterns in ordinary use—(1) Pediment barometer—with straight tube, closed cistern, and no correction for capacity; (2) Pediment barometer with its neutral point, and its capacity correction, marked upon it, and requiring to be computed and applied to each reading; and (3) Pediment barometer with float. In this pattern, the cistern has a leather bag, like a Fortin; and in the cistern, there is an ivory float, the upper part of the stem of which is marked with a horizontal black line; the stem is prolonged above the cistern, and rises between two ivory guides, on which are horizontal lines corresponding to 2 inches of the barometric scale. As the horizontal mark on the stem of the float is 2 inches above the mercury in which it is partly immersed, it follows that when the line on the stem of the float is in one with those on the guides, the mercury in the cistern is level with the zero of the scale; and thus the capacity error was neutralised. The barometers were always of wood, and though (partly for ornament) they generally had attached thermometers, the readings were very rarely corrected for temperature, and I know of no instance of their being reduced to sea-level.

Before leaving this subject, it may be well to mention that in the very year we are considering, our predecessors in this Society, ordered a new barometer—and a very bad one it was, though they paid forty guineas for it. Fortin's ought to have been known to the Council; for, it had already been described in the *Penny Cyclopædia*, and yet they ordered the clumsy pediment barometer, with a capacity correction, the frame of which is exhibited to-night.

Thermometers.—The thermometers for air temperature differed from those now in use in that the bulbs were much larger, the tubes were not backed with white enamel to render the mercury easily visible (that was first done in 1838), and the degree marks were not on the stems. Several thermometers of that date are exhibited.

Thermometer Stands.—Not one of the patterns of thermometer stand now in use was known in 1837—every observer did what he thought best. I will mention a few:—At Swaffham-Bulbeck, Cambridgeshire, the Rev. L. Jenyns (who died only three years since at the age of 94) placed his thermometers on a board (with a pent-house roof over it) standing out from the north side of his house. At the Royal Horticultural Society's gardens at Chiswick, Professor Daniell placed them against the north side of a post which had a spreading oil-cloth cover, like an umbrella. At Sunbury, Middlesex, the Rev. J. Cowe had his thermometer hung against a wall, in a shady nook between two buildings. Mr. Whistlecraft of Thwaite, Suffolk, had some hung against the north side of a wooden shed, and others on a board standing out from a brick wall. The Royal Society's thermometers, at Somerset House, were at a window on the Strand front (*i.e.* facing N. 27° W.). I have not found any description of them, but remember that they were on a board standing nearly at a right angle to the window and guarded, more or less, from morning and evening sun by other projecting boards, one on the east and the other on the west.

Registration of Maxima and Minima.—Two patterns of self-registering thermometers were almost universal—viz. Six's double column thermometer and Rutherford's maximum and minimum;—these two latter not infrequently both mounted on one board. The Six's were much larger than those prepared for window or greenhouse use at the present day; and as the number made was small, and (being expensive) they were carried with care, they were probably less often erroneous than they are now. The Rutherford minimum (with a horizontal tube, the spirit in which in receding draws back a small index), in spite of all attempts to supplant it by a mercurial thermometer, and in spite of its known liability to error, still holds sway; but it has been greatly improved.

The Rutherford maximum has been displaced so thoroughly that we have failed to procure a specimen for exhibition. A steel index was pushed along the tube by the rising mercury, and was left behind when the temperature fell. The theory was right, but in practice the bore of the tube became dirty, the index stuck fast, and the thermometer became useless. Before passing to other instruments it is perhaps worth mentioning, as a link between the present time and about forty years back, that when aluminium was produced, about 1857, as a curiosity and for small articles of jewellery, I remember purchasing a Rutherford's maximum, in which an aluminium index was substituted for a steel one. If my memory is not in error, the tube became oxidised just as did those with a steel index—at any rate the thermometer has disappeared from stations claiming accuracy in their observations, and that is strong evidence that it failed.

Hygrometers.—It has already been shown that the dry and wet bulb hygrometer had been used thirty-five years before the year with which we are concerned, nevertheless it was not at all in general use in 1837—four others were much more common, viz. Daniell's, De Luc's, Saussure's, and Kater's, which I have now to describe.

Daniell's Hygrometer.—This instrument had all the elements of success, as it was the invention of one of the scientific leaders of the time; its manufacture was entrusted to an eminent instrument-maker; and its use was an interesting and pretty experiment. The one used by Sir James South is in the Exhibition. The black glass bulb is nearly filled with ether, some fresh ether is poured upon the other, muslin-covered, bulb, and the evaporation of this ether so cools that bulb, that the ether in the black one volatilises and so becomes cool, and eventually dew is deposited on its bright surface. The temperature of the internal thermometer was supposed to show that of the bedewed surface, and therefore that of the dew-point. For some years, just about the date with which we are concerned, this instrument was much used. But observers found that pure ether was not easily obtained, was with difficulty preserved, and was very expensive.

De Luc's Hygrometer.—This was the hygrometer most generally used. An extremely thin strip of whalebone was fixed rigidly at one end of a brass frame, and at the other end was wound round an axle, to which was attached a pointer which, by the rotation of the axle, traversed a divided circle. The whalebone varied in length according to the humidity of the atmosphere, which was directly indicated upon the divided circle. A specimen, unfortunately without the whalebone, is in the Exhibition.

Saussure's Hygrometer.—Of this instrument there is no specimen of about the correct date (1837), but there is a modern one with hair, counterpoise, etc., in perfect working order. In case any one should not know the principle of this instrument, I may state that a human hair varies in length according as the atmosphere around it is damp or dry; in fact, the arrangement is nearly identical with De Luc's, except that hair is used instead of whalebone.

Kater's Hygrometer was also not infrequently used, and of it there is a specimen in the Exhibition; and as it was not easy to photograph it, our past President, Mr. Inwards, has very kindly drawn the dial and a section showing how it acts—the fragment of *Andropogon contortum* will be seen passing down the centre, and with variations of humidity it causes the hand to travel forwards or backwards.

As regards all these instruments it must not be forgotten that the elasticity of the hygroscopic material gradually fails, so that no two were strictly comparable.

Rain Gauges.—There was more variety in the patterns of rain gauge used in 1837 than there is in 1897. I must not stop to describe them all, but ought not wholly to pass over the subject.

Howard's.—This extremely simple and accurate pattern of gauge was introduced by Luke Howard about 1811, and, either in its original form or in modifications of it, has been made by tens of thousands and erected in all parts of the world. At present, however, we have to deal with it as originally designed by Howard and used in 1837. It consisted of a glass bottle and a copper funnel with a stout brass rim, and, at the base of the cone, an umbrella cap to prevent the rain which runs down the outside of the funnel getting into the bottle, and which also, by fitting tightly on to the neck of the bottle, kept the rim level and prevented the funnel from being blown away. The rain having once passed down the pipe into the collecting bottle is almost entirely protected from loss by evaporation. The measurement is made by pouring the water into a graduated glass jar. This mode of measuring had been adopted nearly 100 years earlier, but to Howard is due the credit of designing a compact and complete instrument.

Crosley's.—Gas was first generally used in London about 1816, and some mode of measuring the quantity taken had to be found; Mr. Crosley was a large manufacturer of gas meters, and about 1829 it occurred to him, that a modification of the wheelwork used in the gas meters, would record the number of times that a tilting bucket was filled by the rain collected by a funnel of suitable size. This was the origin of the Crosley rain gauge, of which several were at work in 1837. They had the serious defect that unless kept scrupulously clean, and the wheels oiled and free from dust, they were liable to stick fast, and then the rain ran through without any record being made. It is greatly to be regretted that a modified form of this gauge has recently been brought out, and is to be seen in some shops, where I should have expected to see only useful and trustworthy instruments.

Float Rain Gauges.—Many of these were in use—both of the "uniform cylinder" and "contracted cylinder" type. They were mostly, if not always, made with the rods attached to the floats; this, when there is much rain in the gauge, leads to the record being too large, because drifting rain, which should have passed over the gauge, is intercepted by the rods and, running down them, falsifies the indication.

Troughton's Side-tube Rain Gauge.—This instrument has for many years been described as "Howard's Side-tube," but I believe that Howard had no more to do with it than Admiral FitzRoy had to do with some wretched barometers to which his name has been attached. The Troughton pattern was brought out in 1835. It has many points of resemblance to a "contracted float," but instead of a float there is a glass tube running up the side, and the water stands at the same level in it as in the cylinder. After reading, it is emptied by the tap at the bottom of the tube. The gauge will not stand frost, and taps are very bad, having a tendency to leak. A specimen is exhibited.

Marshall's Side-tube Gauge.—This was a pattern designed by Mr. J. Garth Marshall for use in the Lake District. An excellent engraving of it will be found in the British Association Report for 1866; it was a very heavy and strong gauge, could hold about a foot of snow in the funnel, and about 25 inches of rain in the body, and was therefore well adapted for that district.

Eccentric Gauges.—I need not occupy time in describing these, but even later than 1837 those in high authority seemed to hold that any one could make a rain gauge, and it is therefore not surprising that the *dii minores* made them after their own imaginations. Few things have given me more pain than having had to tell an observer who had used a hopelessly bad gauge in an equally bad position, that the records which he had kept daily for thirty-four years were absolutely worthless. Happily, what with the inspections made for this Society, for the Scottish Meteorological Society, for the Meteorological Council, and for those in connection with British Rainfall, there is not much chance of the repetition of such a catastrophe.

Anemometry.—This seems to me to be the subject in which least progress has been made, for in 1837 Mr. Follet Osler, F.R.S. (and all who ever knew him will rejoice to learn that he is still with us, and a Fellow of this Society), erected the first of his well-known anemometers at Birmingham. Moreover, it was announced at the Liverpool meeting of the British Association in 1837 that three of Whewell's anemometers were in operation, viz. one each at Cambridge, Edinburgh, and Plymouth. These did not last long; but there are many of Osler's still at work, and in 1882, when Mr. Laughton gave his address on *The History of Anemometers*, it happened that the original 1837 Birmingham Osler had been taken down for repair, and Mr. Osler most kindly sent it to the Society's Exhibition. In 1837 also, Mr. Richard Adie of Edinburgh had made his anemometer upon very nearly the same principle upon which Mr. Dines has lately been working; one of them had, I believe, been ordered for Makerstoun Observatory, and three or four were actually at work at Scotch lighthouses. It may be said that these instruments scarcely come within my definition of an "ordinary equipment." I admit it, but thought that the slight digression would be excused. In 1837 (and I may almost say in 1897), the ordinary anemometric equipment was a weathercock.

Recording Instruments.—Several instruments designed to produce automatic records of meteorological phenomena had been designed and made before 1837, but they were very rare, and scarcely any records made by them now exist. Besides the anemometers just mentioned, I know of one recording barometer, and of two designs for recording rain gauges. With a few words about each I must close my notes upon the instruments of 1837.

Barograph.—The only recording barometer which to my knowledge was at work in this country was that made in 1766 by Alexander Cumming, and purchased from his representatives by Luke Howard. It was a siphon barometer, and I believe that the float on the short leg carried a pencil, which pressed against a circular paper disc rotated by a clock.

Recording Rain Gauges.—Two forms of self-recording rain gauge had been invented before 1837, viz. Bevan's and Donovan's, but I believe that only one of each was ever made; and as there is no reason to think that either of them was at work in 1837, and I have given elsewhere[1] all the information that I could obtain respecting them, it is unnecessary to say more now. Lastly, there was, of course, the rain gauge attached to the Osler anemometer, which was at work, and of which an engraving and full description are given in the work just quoted.

Turning now to the Meteorological Instruments of the present day—I have to speak of forms with which most of my hearers are familiar—that is unavoidable, but statements of this kind are almost invaluable to those engaged in historical research, and, even at the risk of wearying you, I must trouble you with a few details—chiefly, no doubt, for the benefit of our successors in the 20th century.

Our ordinary stations have standard barometer, Stevenson screen containing dry and wet bulb hygrometer, and maximum and minimum thermometers—they also all have a rain gauge. Most of them have in addition thermometers for measuring solar and terrestrial radiation, and the temperature of the soil at one or more feet below the surface.

I will run rapidly over the usual forms of instrument:—

Barometer.—In most cases this is of the Fortin pattern, with glass cistern and leather bag. The scale is divided on the brass tube which protects the barometric tube, and the zero of the scale is the ivory point visible through the glass cistern, and into contact with which the mercury is brought at each observation. The barometer has an attached thermometer, of which the bulb is within the brass tube, and almost in contact with the barometric column. The instruments are all compared with the standard at Kew Observatory, and the corrections, as well as those for temperature, and for altitude above sea, are applied to each reading. The correction for the force of terrestrial gravity is not generally applied. Almost the only other form in use, is that known as the Kew pattern. In it the case is wholly of brass, and the capacity error is neutralised in the construction, the inches on the scale being so shortened that they represent truly the super-elevation of the mercury in the column above that in the cistern. The arrangement of the attached thermometer is the same as that in the Fortin pattern. As long as a Kew barometer remains perfect, it is as good as a Fortin—but if a small leakage from the cistern occurs, erroneous readings may be taken without any indication of error being perceived.

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[1] *British Rainfall*, 1878, pp. 32, 33.

Thermometer Screens.—Very nearly perfect uniformity is now ensured in the exposure of thermometers, and the hygrometer—the pattern of stand known as Stevenson's—is used at almost every station.

Denton's Unchangeable Zeros.—I must mention somewhere, and perhaps this is the most suitable place, the important discovery by the late Mr. Denton of a cure for the old evil of mercurial thermometers. In early times it was supposed that if a mercurial thermometer were free from air and accurately divided it would always remain correct. Then it was discovered that with increasing age they read too high; subsequently it was found that most of the change occurred in the early life of the thermometer, and so to minimise the evil, good makers had the tubes filled and sealed, and left them for two or three years before putting the divisions upon them. But Mr. Denton removed the error entirely, by placing the filled tubes in boiling oil for a week or two—thermometers so treated, and subsequently divided, have not changed 0°·1 in many years. Those, therefore, who desire perfect instruments, can have them if they will pay fair prices.

Hygrometer.—The dry and wet bulb hygrometer has, for regular work, now no rivals—but for experimental research, the condensation hygrometers of Regnault, Alluard, and Dines are used.

I ought not to omit to mention Negretti's excellent invention of the "turn over" hygrometer which is so handy for taking automatically the 9 p.m. observations.

Maximum Thermometer.—When dealing with the instruments of 1837, I pointed out the unsatisfactory character of Rutherford's maximum and did not mention Prof. Phillips's maximum, which was first made in 1832. My reason for so doing was, that though Prof. Phillips had invented and made the thermometer, it was not in use. Proof of that statement is afforded by the fact that in the Great Exhibition of 1851, Six's and Rutherford's were the only thermometers shown which recorded maximum temperatures. Very shortly after the Exhibition closed, and I believe as the result of it, two maximum thermometers were brought before the public, and now all the world over they are practically the only ones used. The first, I believe, was Negretti's, and for nearly all purposes I consider it as perfect as it is underangable, for if it acts once, it must continue to do so until it is broken. There is a small thread of glass dropped into the tube near the bulb, the thermometer stem and the contained thread are softened by heat and bent, whereby the thread is fixed and a sort of trap-door is created, past which the mercury will force its way when the temperature is rising, but past which it will not return until the thermometer is placed bulb downwards.

Prof. Phillips's thermometer lay practically dormant for twenty years, until it was taken up by Mr. Casella, and then it ran Negretti's maximum a very close race. Its principle is well expressed by the name given to it in France (where it was brought out by M. Walferdin) *Thermomètre à bulle d'air.* A very minute speck of air is left in the thermometer, and by manipulation in construction this speck is imprisoned between two portions of the mercurial column. As the thermometer is hung horizontally, this speck acts very much like the thread in Negretti's: when the temperature rises, it and the detached part of the column are pushed along; when the temperature falls, the mercury recedes only from *below* the speck, so that the detached portion remains to indicate the maximum. This thermometer has one inferiority to Negretti's, viz. that sometimes the air speck works its way beyond the detached portion of the column, and then, unless the observer is clever enough to restore it, the thermometer ceases to act as a maximum, and it has to go back to the maker. On the other hand, it can be made with as fine a bore as possible—much finer than Negretti's —and this has led to its almost exclusive use for clinical thermometers. It is also much used for solar radiation thermometers, where smallness of bulb is a desideratum.

Minimum Thermometer.—In ordinary use there is nothing but the Rutherford minimum. For experimental work, and as a perfect *tour de force* in glass-blowing, we have Casella's mercurial minimum, and one or two forms lent by Negretti and Zambra, specimens of each being in the Exhibition.

Rain Gauges.—For ordinary stations two forms are almost exclusively used—in fact I might almost say one form in two sizes, for there is very little difference, except in size, between what is known as a "Modified Glaisher" or "Meteorological Office" gauge and a "Snowdon," except that the former is 8, and the latter 5 inches in diameter. And both are merely evolutions of Howard's. It was seen that if the glass bottle of Howard's cracked, the water would be lost; therefore, if a can were put outside, that evil would be prevented, because the can would hold the water; moreover, the can would protect the bottle, and so breakage would be less probable. Then it was seen that a top must be put to the can in order to prevent both evaporation, and the entry of water which had not passed through the funnel, and as there must be a top it was obvious that the said top would make a very steady support for the funnel. Lastly, it was found that a plain funnel allowed hail to bounce out, and snow to be blown out, and as a cure for the first, and a palliative for the second, we have the Snowdon rim.

The foregoing are what may be considered the essential instruments for an ordinary station. As regards the others I must be very brief; many are in the Exhibition, and are shortly described in the catalogue, and nearly all have been brought before the Society, fully discussed, and described and engraved in the long series of *Proceedings* and *Quarterly Journal* of the Society. Fully to describe all the varieties of meteorological instruments now at work in this country would take several evenings instead of less than half an hour, which alone is available; therefore, obviously, I can do little more than enumerate some of them.

Earth Thermometers.—In the olden time it used to be the practice to have thermometers long enough for their bulbs to be at the required depth, and the top of their tubes above the ground, *i.e.* thermometers 1 ft., 6 ft., 12 ft., and over 25 ft. long. But it has lately been seen that this was not prudent, because, irrespective of the outrageous size of the bulb requisite, and of the extreme difficulty of making and burying such a thermometer, it was absolutely impossible to ascertain whether any changes detected were due to climate, or to index error. Hence latterly it has been usual to plunge a tube to the required depth and lower a short ordinary thermometer (protected from *rapid* change of temperature), and to raise and read it when desired. Nowhere has this system been adopted with such scrupulous regard to accuracy as at Colonel Knight's station near Winchester. This is not the place to discuss the disturbing causes against which he has guarded, some of them very minute—but when I say that with his thermometer at the depth of 70 ft., the difference between summer and winter will probably be much less than 0°·1 F., it will be understood that great care is needed. A photograph in the Exhibition will give some indication of the trouble and cost of the boring for carrying a thermometer down to 70 ft. in the solid chalk. There is also a photograph of another process, being tried, I believe, at the cost of the Meteorological Council.

Solar Radiation.—Forty years ago, when I began meteorological work, solar radiation was measured by getting a Negretti maximum thermometer with a shiny black glass bulb and putting it into the hottest corner you could find—that was not a very comparable process. Then we were advised—(I was told upon the authority of Sir John Herschel, but I never heard it from him, and I do not know where any such statement was made by him)—we were advised I say, to have the thermometers put into a vacuum jacket—but still they were placed on mould, on grass, anywhere and anyhow. The subject was then taken up by Mr. Nunes, and especially by the Rev. W. Fenwick Stow, the result being to decrease the size of bulb, to blacken part of the stem near the bulb, to use dull black instead of shiny, to insist on a high vacuum, to use a similarly mounted bright bulb for comparison, and to mount both, side by side upon a stand, 4 ft. above the ground.

Sunshine.—Latterly this subject, which had been investigated in the first half of the century by Mr. Jordan, has become very popular, and we have rival health resorts striving to show that each has more sun than anywhere else. I am afraid that this rivalry is not altogether beneficial to science; but be that as it may, a very serious disaster has recently befallen sunshine records. There are two processes for recording the duration of sunshine, and each seems to require more care than it has received. One plan is to condense the sun's rays by making them pass through a glass sphere, and focus upon and burn a card placed behind. The disaster is, that, as it is found that some kinds of glass give much better records than others, old records have become untrustworthy. Hence, besides the town rivalry there will also be the question of who has the best glass sphere. The photographic records are, I am told, in an analogous difficulty, as the papers do not appear all equally sensitive.

Terrestrial Radiation.—The experiments upon this subject made by Mr. Glaisher in 1848 have never been surpassed, and the result, the placing of an unmounted Rutherford minimum thermometer over short grass, remains the adopted mode of determining this element—the instrumental record of a white frost. In connection with this I should like to mention a new and capital invention by Mr. Hicks. Observers are aware that the fine lines marking the degrees upon a grass minimum are, owing to the great ranges of temperature and humidity to which it is subjected, very soon washed out. Mr. Hicks has absolutely conquered this difficulty by making the thermometer with *two* bores, one for the spirit as usual, the other behind it a broad flat one, into which he pushes a strip of mica carrying the divisions, and when it is in position he hermetically seals the tube. It is hard to see how any harm can ever come to that scale unless the thermometer be broken.

Anemometers.—Here, also, we are passing through troubled waters, but I think with land in sight. Osler's anemometer was at work in 1837. Some years afterwards the late Rev. Dr. Robinson brought out the well-known Robinson anemometer—four half spheres on radii of a circle, all the hollows facing one way, therefore whenever it was not a dead calm the pressure would be greater in the hollow of the cups than on their exterior, and the system must rotate. Dr. Robinson satisfied himself that the cups travelled with one-third of the velocity of the wind, and hundreds, if not thousands, of anemometers were made the indications being made on the theory of 3 to 1, or, as it is usually expressed, reduced with factor 3. I am not sure as to the dimensions of the cups with which Dr. Robinson experimented, but the practice has been to use factor 3, no matter what pattern of arms and cups was adopted. It now appears that 3 applies only to a few instruments, and that the majority should have been little over 2. Roughly, it comes to this, that when it has been stated that there was a gale of 60 miles an hour, the wind was really blowing about 44 miles an hour. I said that I hoped that land was in sight, and did so chiefly because I have great faith in Mr. Dines, and trust that with his new anemometer there is a prospect of accurate and comparable results.

Evaporation.—In the period between 1837 and 1877, or thereabouts, some terribly bad instruments were used for the purpose of determining the amount dried up from a water surface. With the assistance of Mr. Rogers Field, C.E., and of the Rev. C. H. Griffith, a series of comparisons of the evaporation from these instruments with relation to that from a large tank was undertaken, the result being that all the small instruments proved erroneous, and the large tanks are now in operation at several stations—London; Southampton, Waterworks; Isfield, Sussex; Torquay, Waterworks; and perhaps others. There is also one at the Bureau Central Météorologique in Paris.

Recording Rain Gauges.—There are several excellent patterns of this instrument, and some of them are now made at a moderate price; so that there are nearly 20 stations in the British Isles at which a continuous record is obtained of the time of commencement and termination of every shower, and of the intensity of rain during it. The patterns chiefly used are Beckley's, Casella's, and Richard's.

Storm Rain Gauge.—If the paper is passed rapidly through a recording rain gauge, the length of it which is accumulated is inconvenient; and if it passes slowly, the scale is so close that one cannot read the details for small intervals of time, such as two or three minutes, and yet during thunderstorms much may happen even in a single minute. I therefore designed the storm gauge, which can be read off each fifteen seconds, and each half-minute quite easily. For intense rains it is extremely useful.

Recording Barometers, Thermometers, etc.—This is a vague title, but time will not permit more than a very vague general statement. About 1840-50 two men were working at self-recording instruments—Charles Brooke, F.R.S., and Sir Francis Ronalds, F.R.S. Each employed photography; the instruments of the former were adopted at Greenwich, and modifications of some of Ronalds' were adopted by the Meteorological Council; but they were all very costly—far beyond the reach of ordinary observers. The first approach to a moderate price was made by Mr. Martin, who showed a self-recording aneroid at the British Association meeting at Exeter in 1869. But it is to Messrs. Richard of Paris that the popularisation of recording meteorological instruments is due—they have done more in that direction than all other opticians in the world put together; and though for thousandths of an inch of the barometer, or tenths of a degree of the thermometer, we must still look to photography: MM. Richard give us pressure, temperature, humidity, rain, wind, solar radiation, evaporation, in fact almost everything, at from a fourth to a tenth of the cost of the older patterns.

Photography.—The remainder of my remarks depends almost wholly upon photography, to which we owe so much. Mr. Birt Acres has kindly promised to show you the very last development in this department, therefore I will say nothing to anticipate him.

Clouds.—Luke Howard, early in the century, gave us the nomenclature of clouds which, with little modification, is now universally adopted. But of late years much has been done in the way both of the representations of the forms of clouds, and in the measurements of their height; and in each branch photography has been most useful. I must not stop to show forms of clouds, but the cloud cameras of Mr. Clayden and of M. Teisserenc de Bort will give some idea of the development of this branch of meteorological work.

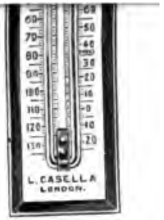
Experimental Work.—When commencing this lecture I pointed out that it was impossible to make it satisfactory. Here is a confirmation of my remark. I ought to give an epitome of experimental meteorology, and should have liked to refer not merely to that in this country, but in others, such for instance as the cloud survey in which England is doing so little; the French and German balloon experiments; the Kite work originated in Scotland, advanced in England by Douglas Archibald, and now greatly developed in the United States, both at Blue Hill Observatory and by the Weather Bureau; our own work on anemometers on the "Worcester," etc.,—but I must not stop to do so.

Snow Crystals.—Something of the beauty of these "Flowers of the Sky," as Tyndall so appropriately named them, was known early in the century, and I reproduce an engraving by Scoresby dated 1830, and follow it by the latest development of this branch of research, three photographs taken direct from the snow crystals themselves. For these I am indebted to Dr. Hellmann, a copy of whose beautiful book *Schneekrystalle* is in the Exhibition.

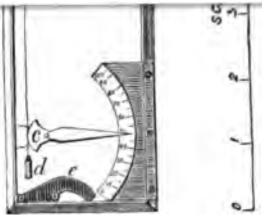
Weather Map.—Lastly, I have to show that which may in many respects be regarded as the essence of much that has gone before, and of the marvellous progress which has characterised the Victorian reign. Thanks to the help of Mr. Scott and Mr. Gaster I am able to show the state of the weather over Western Europe only three hours ago. We are so used to weather maps that they do not strike one as at all a marvel, but when we look into the details, they really are startling. We have here records for this evening from the sunny Riviera, eastwards as far as Berlin, and northwards, not merely up to the top of the Gulf of Bothnia, but actually up to Bodo within the Arctic circle. If this does not prove the existence of wide-spread interest in meteorological work, excellent organisation, and the wonderful development of human intercourse, I do not know how otherwise it could be demonstrated.

NOTE.—This lecture was illustrated by numerous photographs of instruments and other objects. A few of them are reproduced on Plates II. and III.

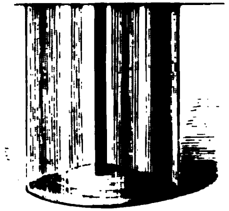
Pediment Barometer.



Six's Thermometer.



Saussure's Hygrometer.



Howard's Rain-Gauge.

Exhibition of Meteorological Instruments in use in 1837 and in 1897,

Held in Commemoration of The Diamond Jubilee of H.M. the Queen, at the Institution of Civil Engineers, Great George Street, Westminster, March 16th to 19th, 1897.

INSTRUMENTS IN USE—1837.

BAROMETERS.

1 **Pediment Barometer,** with large spirit thermometer. The thermometer has an arbitrary scale decreasing as the temperature increases. "Extream cold" being 90°, and "Extream hot," 0°.
Exhibited by Sir E. H. Verney, Bart., F.R.Met.Soc.

2 **Pediment Barometer,** made by Daniel Quare.
Exhibited by The Meteorological Council.

3 **Morland's Diagonal Barometer,** the top part of the tube of which is inclined from the perpendicular to give an enlarged scale reading.
Exhibited by Messrs. Negretti & Zambra.

4 **Pediment Barometer,** made by J. Long, Martin's Lane.
Exhibited by E. Mawley, Pres.R.Met.Soc.

5 **Portable Newman Barometer.**—The tube is uncontracted, 0·4 in. in diameter, with 0·25 in. bore, and is tightly embedded in mahogany and protected by sliding covers. The scale is of flat brass, and extends from 19 ins. to 32 ins. The vernier slides up and down the scale, friction tight, fine motion being imparted to it by a long screw lying at the back of the scale, the head of which projects through the top of the instrument. The cistern is closed, is cased in brass, and is provided with Newman's arrangement for portability.
Exhibited by Sir E. H. Verney, Bart., F.R.Met.Soc.

6 **Large Cistern Barometer.**—This instrument was made for the Meteorological Society of London in 1837 by Mr. R. C. Woods, and cost forty guineas. The proportion of the calibre of the tube to that of the cistern is as 1 : 50, a proportion which was considered sufficient to obviate the necessity for applying capacity corrections. The tube and cistern originally held 70 lbs. of mercury.
Exhibited by The Royal Meteorological Society.

THERMOMETERS.

7 **Original Centigrade Thermometer by Gay Lussac.**
Exhibited by G. J. Symons, F.R.S.

8 **Mercurial Thermometer,** presented to the Royal Meteorological Society by Mr. W. Ellis, F.R.S. This instrument is probably 100 years old.
Exhibited by The Royal Meteorological Society.

9 **Spirit Thermometers** used at Messrs. W. G. and J. Strutt's mills, Belper :—
1. Dated on back, July 10, 1823.
2. Purchased in 1818 from Bregazzi, Derby, at a cost of 6s.
3. Purchased in 1824 at a cost of 5s. New paper scale made from the old one, December 1880. *Exhibited by* J. HUNTER, F.R.Met.Soc.

10 **Phillips's Maximum Thermometer,** made by Prof. J. Phillips, F.R.S., himself, 1832. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

11 **Metallic Thermograph,** made by Mr. N. S. Heineken in 1837. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

12 **Six's Self-registering Maximum and Minimum Thermometer.** *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

13 **Maximum and Minimum Thermometer** formerly belonging to the late Sir James Ross. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

HYGROMETERS.

14 **Weather House Hygrometer.** *Exhibited by* W. MARRIOTT, F.R.Met.Soc.

15 **Swan Quill Hygrometer.** *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

16 **Saussure's Hair Hygrometer.**—This consists of a brass frame with a hair fastened at one end by an adjustable screw, and at the other passed round a wheel carrying a long arm which travels over a graduated arc. A counterpoise weight is used to keep equal tension upon the hair. [Modern pattern.] *Exhibited by* G. J. SYMONS, F.R.S.

17 **De Luc's Whalebone Hygrometer.** *Exhibited by* G. J. SYMONS, F.R.S.

18 **Kater's Hygrometer.**—Designed by Captain Kater, F.R.S. The motive power is furnished by a twisted filament of an Indian grass, *Andropogon contortum.* *Exhibited by* G. J. SYMONS, F.R.S.

19 **Leslie's Hygrometer.**—A glass tube bent siphon-fashion is fixed with the bend downwards. Each upper extremity terminates in a hollow bulb. The tube contains rather more than enough coloured sulphuric acid to fill the whole of one leg. One of the bulbs is of blue glass, the other is covered with wet muslin like a wet bulb thermometer ; the result of the cooling thereby produced is to cause the air in that bulb to contract, and the liquid to rise in the vertical tube of which it is the terminal. Hence the readings indicate the rate of evaporation. This is an application of Leslie's Differential Thermometer. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

20 **Daniell's Hygrometer.**—This consists of a glass tube bent at right angles at two points, with a bulb at each extremity. One of the bulbs, which is of black glass, is nearly filled with ether, in which is placed the bulb of a thermometer ; the other bulb is covered with muslin. This muslin being wetted with a few drops of ether, evaporation takes place, which quickly cools the bulb, and thus condenses the vapour of the ether within. In consequence of this the ether inside the other bulb evaporates, and its temperature being thereby reduced, a ring of dew begins to be formed outside the black glass bulb. At this instant, the thermometer inside is to be read, as the reading gives the dew-point of the air at the time, and the temperature of the air is to be read from the thermometer attached to the pedestal of the instrument. *Exhibited by* G. J. SYMONS, F.R.S.

21 **Jones's Hygrometer.**—The tube of the thermometer is bent so as to bring its bulb vertical and parallel with its stem. The bulb is 1 in. long and of a conical shape, with a flattened top or surface of black glass projecting a little beyond the sides. Below the flat surface this bulb is covered with black silk. The hygrometer is mounted and supported on a brass stand in such a manner that the black surface can be inclined towards the light. When used the thermometer is first to be read, ether is then poured on the silk cover of the bulb, and the condensation of moisture takes place upon the black surface of the bulb. Then by again noting the temperature the dew-point may be known.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

22 **Early Pattern of Dry and Wet Bulb Hygrometer.**
Exhibited by G. J. SYMONS, F.R.S.

RAIN GAUGES.

23 **Howard's Rain Gauge.**—Designed by Luke Howard, F.R.S., and engraved in the first edition of his *Climate of London*, published in 1818. The area of the funnel is about eleven times that of the measuring jar, so that minute measurements are possible.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

24 **Crosley's Registering Rain Gauge.**—The area of this gauge is 100 ins., and beneath the tube leading from the funnel there is a vibrating divided bucket; when one compartment has received a cubic inch of water, *i.e.* when 0·01 in. of rain has fallen, the bucket tips, the index advances on the first dial, and the other bucket begins to fill, and so on indefinitely.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

25 **Side-tube Rain Gauge.**—The water passes into the body of the gauge, and also into the glass tube, and stands at the same level in each. As the combined area of these tubes is very much less than that of the receiving surface, the natural depth of the rain is proportionally increased, and thus the scale is lengthened in proportion—usually about eight or ten times,—so that the quantity can be read off to hundredths of an inch. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

ANEMOMETERS.

26 **Lind's Anemometer,** in which the force of the wind is shown by the depression and elevation of a column of water above and below the zero of the scale. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

27 **Anemoscope, or Portable Wind Vane,** with compass, etc., for use of travellers. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

28 **Whewell's Anemometer.**—A horizontal brass plate is attached to a vertical spindle, which passes through the axis of a fixed cylinder, being supported by a bearing at the lower end, and working in a collar at the upper. A vane is attached, by which the plate is moved about according to the direction of the wind. A fly, having eight fans, each fixed at an angle of 45° with the axle, is placed upon the plate so that the axle is in the line of direction of the vane. An endless screw on the axle turns a vertical wheel having 100 teeth, the axle to which has

also an endless screw working into a horizontal wheel, having a number of teeth, and which communicates motion to a vertical sc 15 inches long. On this screw is placed a movable nut which ca a pencil. Round the cylinder is wrapped daily a paper divided for points of the compass. The wind acting upon the vane causes the p to turn; and the screw which carries the pencil travels with it, so t the pencil marks upon the paper the direction and velocity of the wi The fly also is set in motion, and thereby the nut upon the screw desc so that the attached pencil traces a vertical line upon the paper. T instrument was used at the Royal Observatory, Greenwich, from 18 to 1862. *Exhibited by* W. H. M. Christie, F.R.S., Astronomer Roy

ACTINOMETER.

29 **Herschel's Actinometer,** for ascertaining the absolute heating effect the solar rays, in which time is considered one of the elements of servation. The instrument consists of a large cylindrical thermom bulb, with a very open scale, so that minute changes may be easily se The bulb is of transparent glass filled with a deep blue liquid, which expanded when the rays of the sun fall on it. When taking an obse tion the actinometer is shaded for one minute and read off; it is t exposed for one minute to sunshine, and its indication recorded; finally shaded again, and its reading noted. The mean of the readings in the shade, subtracted from that in the sun, indicates expansion of the liquid produced by the sun's rays in one minute time. *Exhibited by* The Kew Committ

INSTRUMENTS IN USE—1897.

BAROMETERS.

30 **Fortin Barometer,** with adjustable cistern for bringing the surface of the mercury to the ivory point which forms the extremity of the scale.
Exhibited by L. P. Casella, F.R.Met.Soc.

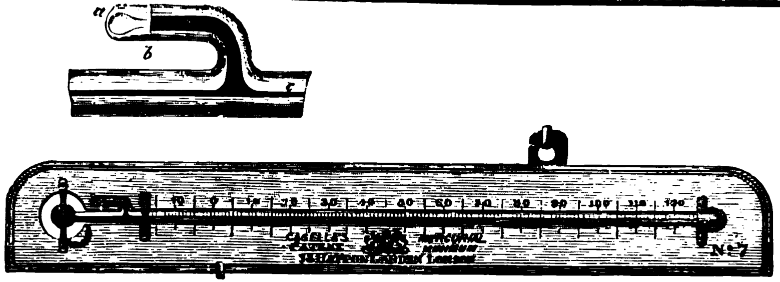
31 **Mountain Barometer,** Fortin pattern, in aluminium case.
Exhibited by L. P. Casella, F.R.Met.Soc.

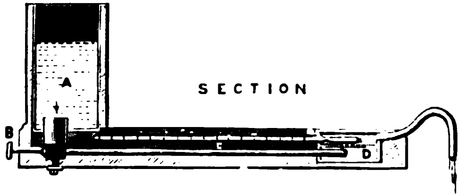
32 **Kew Barometer,** first designed in 1853, tube 0·4 in. in diameter. In this instrument the cistern is closed and the scale contracted, to obviate the necessity of correction for capacity.
Exhibited by L. P. Casella, F.R.Met.Soc.

33 **Student's Barometer,** Kew pattern, with bold metal scales.
Exhibited by L. P. Casella, F.R.Met.Soc.

34 **Siphon Barometer,** Gay Lussac's principle.
Exhibited by Messrs. Negretti & Zambra.

35 **Boylean Mariotte Barometer.**—This instrument, which was invented by T. Telford Macneill, consists of a short central glass tube, a lower open-air tube or bulb, with diaphragm joined to it, covered with wood and a brass tube enveloping the glass, and on which the scale is engraved. Attached to this is a cistern filled with mercury, which has a stopcock and a screw adjustment. The total length of the instrument is from 12 to 15 ins., but for convenience of carriage the cistern can be detached and carried separately. The atmospheric pressure is measured





Dines' Hygrometer.

by an uniform volume of air being admitted to the cistern, and compressed by the advance of the mercury to a fixed point. The readings are taken as in the Fortin barometer.

Exhibited by L. P. Casella, F.R.Met.Soc.

36 **Self-compensating Barometer.**—This consists of the usual form of instrument, but with a double rack moved by one pinion, so that when adjusting the vernier in one position the second rack moves in the opposite direction, carrying along with it a plunger which is the exact size of the internal diameter of the tube. This dips into the cistern, so that whatever displacement has taken place in the cistern owing to the rise or fall of the mercury, it is exactly compensated by the plunger being more or less immersed in the mercury; and consequently no capacity correction is required.

Exhibited by Messrs. Negretti & Zambra.

37 . . . . . .

38 **Howson's Long Range Barometer.**

Exhibited by Messrs. Negretti & Zambra.

39 **Long Range Mercurial and Glycerine Barometer.**—This is really a siphon mercurial barometer, but to the short end is joined a length of glass tubing of smaller diameter. This smaller tube is partly filled with glycerine, which is many times lighter in specific gravity than the mercury. A longer range is consequently obtained, due both to the unequal capacity of the two tubes and the difference in the specific gravity of mercury and glycerine.

Exhibited by Messrs. Negretti & Zambra.

40 **Bartrum's Open Scale Barometer.**

Exhibited by J. J. Hicks, F.R.Met.Soc.

41 **Calendar's Sulphuric Acid Barometer.**

Exhibited by J. J. Hicks, F.R.Met.Soc.

42 **Jordan's Glycerine Barometer.**—The upper part of the tube only is shown, as the instrument, when complete, would be about 30 ft. in height.

Exhibited by J. J. Steward, F.R.Met.Soc.

43 **Wallis's Barometer Adjunct.**—This instrument was designed to overcome a difficulty which many observers experience, in accurately adjusting the mercury to the ivory point in the cistern of a Fortin barometer. It consists of a small microscope which clamps to the cistern.

Exhibited by L. P. Casella, F.R.Met.Soc.

THERMOMETERS.

44 **Standard Thermometer.** *Exhibited by* Messrs. Negretti & Zambra.

44* **Maximum and Minimum Thermometers,** for use on board ship.

Exhibited by The Meteorological Council.

45 **Maximum Thermometers, Negretti & Zambra's principle,** as used in 1854. *Exhibited by* H. Perigal, F.R.Met.Soc.

46 **Rutherford's Minimum Thermometer** as used in 1854.

Exhibited by H. Perigal, F.R.Met.Soc.

47 **Casella's Maximum Thermometer, Phillips' principle.**—The index is formed by a small portion of the mercurial column, separated from the main thread by a minute air bubble; this portion is pushed on before the column when it expands, but does not return with it when it contracts.

Exhibited by L. P. Casella, F.R.Met.Soc.

48 **Casella's Mercurial Minimum Thermometer.**—At a short distance from the bulb a small bent tube with a large bore joins the indicating tube. At the upper end of this bent tube there is a flat glass diaphragm, which is formed by the abrupt junction of a small chamber, the inlet to which is larger than the bore of the indicating tube. The result of this is that on the thermometer being set, the contracting force of the mercury in cooling withdraws the fluid in the indicating stem only, whilst on its expanding with heat the long column does not move, the increased bulk of mercury finding an easier passage through the larger bore into the small pear-shaped chamber attached.
Exhibited by THE ROYAL METEOROLOGICAL SOCIETY.

49 **Negretti and Zambra's Mercurial Minimum Thermometer.**—A small vertical tube is connected with the indicating tube at right angles, about one inch from the bulb; in this tube is inserted a platinum plug. On a decrease of temperature, the mercury falls in the large tube until it attains its lowest point; and on an increase of temperature, the mercury rises in the small tube, leaving the indicating column in the large tube registering the minimum temperature.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

50 **Negretti and Zambra's Improved Vertical Minimum Thermometer.**
Exhibited by Messrs. NEGRETTI & ZAMBRA.

51 **Black Glass Bulb Maximum Thermometer.**
Exhibited by Messrs. NEGRETTI & ZAMBRA.

52 **Bifurcated Grass Minimum Thermometer.**—Extra sensitive, for observations of terrestrial radiation.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

53 **Sensitive Minimum Thermometer,** with cylinder bulb.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

54 **Minimum Thermometer with link bulb** and hermetically sealed shield.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

55 **Hollow Cylinder Bulb Minimum Thermometer.**
Exhibited by J. J. HICKS, F.R.Met.Soc.

56 **"Climax" Thermometers** with the divisions and figures hermetically sealed in the glass. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

57 **Self-registering Combined Maximum and Minimum Thermometer,** on boxwood scale. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

58 **Six's Thermometer** with bulbs reversed to record "yesterday's" and "to-day's" temperatures for comparison.
Exhibited by J. J. HICKS, F.R.Met.Soc.

59 **Negretti and Zambra's Turn-over Thermometer.**—Original pattern, reversible by clock. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

60 **Negretti and Zambra's Electrical Recording Thermometrical Apparatus.**—This consists of six turnover thermometers mounted on a stand, with a clock and battery. Each thermometer is fixed in such a manner that it will fall over and become inverted, on the release of a detent, by the joint action of the clock and battery.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

61 **Richard's Thermograph.**—The thermometer consists of a very thin curved metal case (a Bourdon tube) containing alcohol, one end being a fixture and the other movable. As the alcohol expands or contracts with the changes of temperature it alters the curve of the tube, making it flatter or otherwise. The end of the tube communicates its motion by means

of a metal rod to a lever carrying a pen, which marks a graduated paper wound on a cylinder. A clock turns the cylinder round once in seven days. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

62 **Richard's Thermograph,** small size, in wooden case. *Exhibited by* Messrs. J. LEVI & Co.

63 **Thermograph,** English make. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

HYGROMETERS.

64 **Dry and Wet Bulb Thermometers.** *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

65 **Screen with Dry and Wet Bulb Thermometers for use on board Ship.** *Exhibited by* THE METEOROLOGICAL COUNCIL.

66 **Dry and Wet Bulb Thermometers,** fixed to doors of small mahogany case, for use of travellers. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

67 **Dry and Wet Bulb Thermometers,** with metal case and protected bulbs, for use in factories, hospitals, etc. *Exhibited by* Messrs. JOHN DAVIS & SON.

68 **Negretti and Zambra's Electrical Turnover Dry and Wet Bulb Thermometers.**—This consists of a dry and wet bulb thermometer (constructed on the principle of Messrs. Negretti and Zambra's deep sea registering thermometer) attached to a carrier and actuated electrically by a timepiece. This may be set for any hour, and at the proper time it will cause the thermometers to turn upside down, and thus record the temperatures at that moment. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

69 **Casartelli's Mill Hygrophant.**—This consists of dry and wet bulb thermometers, between which there is a revolving cylinder containing a printed table of percentages. A graduated scale of the reading of the dry bulb is affixed at one side. To ascertain the percentage of humidity at any temperature, it is only necessary to take readings of the dry and wet bulb thermometers, and note the number of degrees of difference between the readings. The figure corresponding to this difference is then brought to the top of the revolving cylinder, and the percentage of humidity at any reading of the dry bulb from 30° to 100° is read off by means of the graduated scale at the side. *Exhibited by* W. W. MIDGLEY, F.R.Met.Soc.

70 . . . . . .

71 **Dines' Dew-point Hygrometer.**—A little water and ice, or cold water only, is put into the cup and allowed by a tap to flow gently through a small chamber, whence it rises through a perforated diaphragm into the space under a slab. In this space, which is covered water-tight by a thin smooth piece of silver, or of black glass, rests the bulb of a sensitive thermometer, the water flowing gently from the spout cools the cover and the contained thermometer; when the temperature reaches the dew-point, a decided film of dew will be visible, the temperature being shown by the thermometer. The tap enables the rate of flow of the water to be regulated with accuracy, and the temperature of the water under the glass slab to be thereby kept at any required point. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

72 **Dines' Dew-point Hygrometer, with latest improvements.**—This instrument can be used with water, but has been designed mainly for use with ether. When ether is used, it is poured down the inclined pipe, and remains in the front part of the chamber. A piece of metal tube, ground so as to fit closely the inclined pipe, and with an aspirator attached, is then inserted, and the dew-point is ascertained in the same way as by Regnault's hygrometer. (*Quarterly Journal Roy. Met. Soc.*, vol. vi. p. 39.) *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

73 **Richard's Self-recording Hair Hygrometer.**—The recording portion is similar to that of the barographs and thermographs made by this firm. The actuating portion is a wisp of about a dozen hairs fastened at each end, and stretched laterally by a small weighted lever, the elongation and contraction of the hairs causes motion of the lever, and is thereby recorded on the cylinder. *Exhibited by* Messrs. J. LEVI & Co.

74 **Richard's Self-recording Dry and Wet Bulb Thermograph.**—This consists of a pair of thermometers, which are placed side by side; but they are curved reversely, and are placed as far apart as possible. The wet bulb thermometer is covered with muslin, and is kept moist by a water vessel below into which the muslin dips, and also by a capillary siphon from a second water vessel above.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

RAIN GAUGES.

75 **Glaisher's Rain Gauge (earliest form)**, with bevelled rim and curved pipe. The rim round the gauge, about two-thirds of the way up, was designed to make a water-tight joint, so as to prevent any of the rain inside escaping by evaporation. The same object was aimed at by the curved tube or inverted siphon, in which the last few drops of rain remained and (until they dried up) formed a water-seal.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

76 **Meteorological Office Gauge.**—This is generally regarded as the best gauge for ordinary observers to whom cost is not a primary object.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

77 **Snowdon Rain Gauge**, with deep funnel for collecting snow.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

78 **Galvanised Iron Snowdon Gauge.**—The special features of this gauge are, that while it is accurate, and will last for 15 or 20 years, its cost is very small. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

79 . . . .

80 **Livingstone's Rain Gauge.**—This is a 3-inch copper gauge with upright rim, copper receiver, and glass measure, as made for the late Dr. Livingstone. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

81 **Richard's Self-recording Rain Gauge**, balance pattern.—This consists of a funnel and pipe leading the rain into a tipping bucket divided into two compartments and placed on a balance. One of these compartments being under the funnel, the rain falls into it and causes the balance to descend; a writing pen records this motion on the revolving drum. When the pen has reached the top (0·4 in. of rain) the tipping bucket reservoir oscillates, and the water filling the first compartment is emptied into a controlling reservoir. This motion causes the second or empty compartment of the bucket to place itself under the funnel. The filling

and emptying of each compartment is alternately and automatically produced, and to each of these double operations corresponds a rise and a fall of the writing pen. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

ANEMOMETERS.

82 **Robinson's Anemometer,** with two dials for recording the velocity of the wind. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

83 **Beckley's Anemometer,** with improvements, recommended by the late Mr. G. M. Whipple. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

84 **Dines' Pressure Tube Anemometer.** Recording pattern. (See *Quarterly Journal,* vol. xviii. p. 165.) *Exhibited by* R. W. MUNRO, F.R.Met.Soc.

85 **Dines' Pressure Tube Anemometer, indicating the Velocity at sight, and also registering the Maximum.** (See *Quarterly Journal,* vol. xix. p. 16.) *Exhibited by* R. W. MUNRO, F.R.Met.Soc.

86 **Dines' Portable Pressure Tube Anemometer.** *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

87 **Electrical Anemometer and Wind Vane.** *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

88 **Richard's Cinemograph,** with dials. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

89 **Richard's Anemometer.**—The vane and helicoid fans only are shown. *Exhibited by* Messrs. J. LEVI & Co.

90 **Biram's Anemometer.** *Exhibited by* Messrs. JOHN DAVIS & SON.

91 **Davis's Self-timing Anemometer.** *Exhibited by* Messrs. JOHN DAVIS & SON.

92 **Capell-Davis Anemometer for ascertaining Velocities over 30 ft. per second.**—This instrument is designed to test such high velocities as would endanger the Biram or Davis's Self-timing Anemometer. The instrument is 4 ins. in diameter and reads to ten million feet. *Exhibited by* Messrs. JOHN DAVIS & SON.

NEPHOSCOPES.

93 **Goddard's Cloud Mirror.** *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

94 **Finemann's Nephoscope.**—This consists of a tripod standing on levelling screws, bearing a compass needle in a circular brass frame movable round a vertical axis. The lid of the compass case is formed of a mirror of black glass provided with a small circular window of clear glass through which the point of the needle is observed. The mirror bears on its surface radial lines for the principal points of the compass, and three circles distant 26·8 mm. from each other. At the extremity of the diameter passing through the window, and opposite to it, is a vertical graduated scale moved by a ratchet wheel and milled head screw. The scale is raised or lowered till the image of a cloud seen at the centre of the mirror exactly coincides with the end of a line passing from the observer's eye through a point of the scale to the centre of the mirror. *Exhibited by* THE METEOROLOGICAL COUNCIL.

95 **Photo-Nephograph, designed by Capt. Abney, F.R.S., for the Regi tion of the Velocity and Direction of Motion of Clouds.** (See *Re of the Meteorological Council* for the years 1879 and 1881.)
Exhibited by THE METEOROLOGICAL COUN

96 **Camera for photographing Clouds and Lightning,** with a mirror black glass attached. *Exhibited by* A. W. CLAYDEN, F.R.Met.S

SUNSHINE RECORDERS.

97 **Campbell-Stokes Sunshine Recorder.**—This consists of a sphere of g 4 inches in diameter, supported on a pedestal in a metal zodiacal fr which is grooved for holding the cards.
Exhibited by THE METEOROLOGICAL COUN

98 **Sunshine Recorder,** with adjustments for use in any latitude.
Exhibited by Messrs. NEGRETTI & ZAMB

99 **Whipple-Casella Sunshine Recorder.**—The instrument is furnished w divided latitude and declination circles, and thus can be easily set f any locality and for any day in the year.
Exhibited by L. P. CASELLA, F.R.Met.So

100 **Jordan's Sunshine Recorder.**—This instrument consists of a cylindric box, on the inside of which is placed a strip of cyanotype paper. Su light being admitted into this box by two small apertures, is received o the paper, and travelling over it by reason of the earth's rotation, leave a distinct trace of chemical action.
Exhibited by Messrs. NEGRETTI & ZAMBRA

101 **Jordan's Sunshine Recorder,** new pattern.—The improvement in thi instrument over the former consists in using two hemi-cylindrical boxes one to contain the morning and the other the afternoon record. A aperture for admitting the beam of sunlight is placed in the centre o the rectangular side of each box, so that the length of the beam within the chamber is the radius of the cylindrical surface on which it is projected; its path therefore at all seasons follows a straight line on the paper. The hemi-cylinders are placed with their diametral planes at an angle of 60°. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

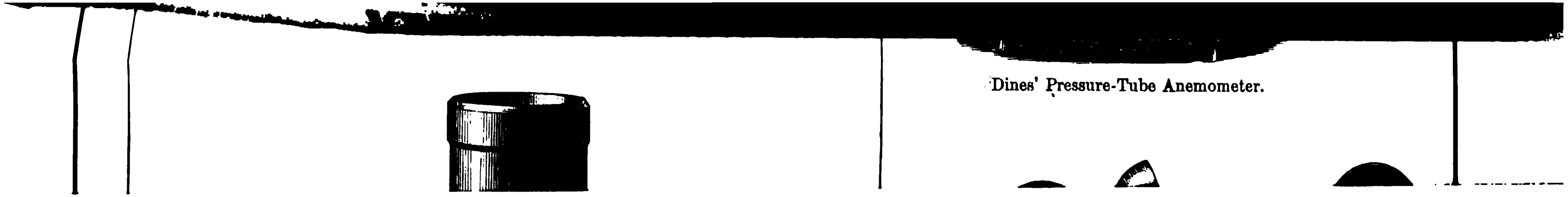
ACTINOMETERS.

102 **Pouillet's Direct Pyrheliometer.**—This instrument is composed of a shallow cylinder of steel which is filled with mercury. Into the cylinder a thermometer is introduced, the stem of which is protected by a piece of brass tubing. As the surface on which the sun's rays fall and the quantity of mercury within the cylinder are both known, the effect of the sun's heat upon any area can be expressed by stating that it is competent in five minutes to raise a given quantity of mercury so many degrees in temperature. *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

103 **Black and Bright Bulb Thermometers in vacuo,** mounted in an upright position with the bulbs uppermost (as used at the Montsouris Observatory, Paris). *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

104 **Solar Radiation Thermometer in vacuo,** with mercurial test gauge.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

105 **Richard's continuously recording Black and Bright Bulb Solar Radiation Thermometers.** *Exhibited by* Messrs. J. LEVI & Co.



Dines' Pressure-Tube Anemometer.

106 **Hicks's Black-bulb Maximum Thermometer in vacuo,** with platinum wires and battery for testing the vacuum.
Exhibited by J. J. Hicks, F.R.Met.Soc.

SETS OF INSTRUMENTS.

107 **Climatological Station.**—Enclosure with instruments necessary for the equipment of a Climatological Station of the Royal Meteorological Society, viz.—

Stevenson Thermometer Screen, fitted with—
  Dry Bulb Thermometer.
  Wet Bulb „
  Maximum „
  Minimum „
Rain Gauge and Measuring Glass.
Black and Bright Bulb Thermometers.
Grass Minimum Thermometer.
Campbell-Stokes Sunshine Recorder.
Earth Thermometer.

Exhibited by The Royal Meteorological Society.

108 **Case for holding Meteorological Instruments under a Thatch Shelter at Stations in Tropical Africa.**—The dimensions are such that all the instruments, including the rain gauge, can be sent inside; the stand is wholly of metal, so as not to be deranged by changes of the hygrometric condition of the air. *Exhibited by* L. P. Casella, F.R.Met.Soc.

109 **Traveller's Companion,** consisting of a leather case containing Aneroid, Thermometer, and Compass.
Exhibited by Messrs. Negretti & Zambra.

ANEROIDS.

110 **Aneroid,** showing mechanism. *Exhibited by* L. P. Casella, F.R.Met.Soc.

111 **Aneroid,** pocket size. *Exhibited by* L. P. Casella, F.R.Met.Soc.

112 **Aneroid,** in aluminium case with scale of heights, etc.
Exhibited by L. P. Casella, F.R.Met.Soc.

113 **Aneroid, with Altitude Scale.**
Exhibited by Messrs. Negretti and Zambra.

114 **Aneroid,** with vernier attachment to scales.
Exhibited by J. J. Steward, F.R.Met.Soc.

115 **Field's Engineering Aneroid.**—In this instrument the scale of altitudes is movable, but instead of being shifted at pleasure, according to the position of the index, it is moved into certain fixed positions according to the temperature of the air, so that the shifting of the scale answers the same purpose as if the original scale were altered to suit the various temperatures of the air. The outer movable scale is graduated in feet for altitudes, and the graduation is laid down by fixing the zero opposite 31·0 ins. This is the normal position of the scale, and it is correct for a temperature of 50°. For temperatures below 50° the zero of the scale is moved below 31·0 ins.; and for temperatures above 50° it is moved above 31·0 ins. In order to insure the altitude scale not being shifted after it has once been set in its proper position, there is a contrivance for locking it in the various positions. The altitudes are in

all cases determined by taking two readings, one at each station, and then subtracting the reading at the lower station from that of the upper. (*Quarterly Journal Met. Soc.*, vol. ii. p. 10.)
Exhibited by ROGERS FIELD, F.R.Met.Soc.

116 **Watkin Aneroid, with open Scale.**—Instead of the usual one-circle of figures, the scale of this instrument consists of a spiral of three complete turns. On the aneroid being put under an air-pump or taken up a mountain, the point of the index is gradually drawn *towards* the centre, so that it follows the *decreasing* spiral scale; but when the index moves in the opposite direction the point moves *away* from the centre, thus following the *increasing* spiral. This is effected by the index-hand being made to slide in and out, so that one end may advance or recede from the centre and thus follow the spiral scale. Attached to the spindle is a cross-piece, in which the index slides, and a hollow drum fixed to the dial plate has a flexible chain or cord wound round it, the ends being fastened to the projecting pins rivetted to the index; consequently, if the spindle and the piece attached to it is revolved, one portion of the chain or cord winds off the drum, the other being wound on to the same extent, and the index is caused to slide through the cross-piece, the direction of motion being controlled by the direction in which the spindle is revolved. *Exhibited by* J. J. HICKS, F.R.Met.Soc.

117 **Blakesley's Surveying Aneroid,** with altitude scale, adjustable to varying air temperatures. The instrument is provided with a movable altitude scale graduated to a given air temperature, the pressure scale being divided into equal parts. The zero of the altitude scale is displaced a given amount in accordance with the observed temperature, and differences of level between two stations are read off on the scale without having recourse to calculation. *Exhibited by* J. J. STEWARD, F.R.Met.Soc.

118 **Richard's Self-recording Aneroid.**—This instrument consists of a series of vacuum boxes by which the effects of the atmospheric pressure are increased and transmitted by a system of levers to an arm carrying a pen. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

119 **Richard's Self-recording Aneroid,** in metal case.
Exhibited by Messrs. J. LEVI & Co.

120 **Self-recording Aneroid,** English make.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

121 **Self-recording Aneroid Barometer.**
Exhibited by J. J. HICKS, F.R.Met.Soc.

ELECTRICAL AND MISCELLANEOUS INSTRUMENTS.

122 **Gold Leaf Electroscope.** *Exhibited by* Messrs. NEGRETTI & ZAMBRA.

123 **Electrical Apparatus employed by Sir Francis Ronalds** at the Kew Observatory, Richmond, Surrey. *Exhibited by* THE KEW COMMITTEE.

124 **Thomson's Quadrant Electrometer with Replenisher.**—This instrument was used in conjunction with a water-dropping collector for photographically recording atmospheric electricity at the Kew Observatory from 1874 to 1885. It is described with illustrations in the *B. A. Report* for 1867, p. 489. *Exhibited by* THE KEW COMMITTEE.

125 **Ozonometer,** with strips of paper prepared with iodide of potassium and starch exposed in a cage of fine wire gauze.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

126 **Rain-band Spectroscope.** *Exhibited by* L. P. Casella, F.R.Met.Soc.

127 **Seismograph** as arranged by Prof. J. Milne, F.R.S., for recording earthquakes, earth-tremors, etc. *Exhibited by* L. P. Casella, F.R.Met.Soc.

128 **Thomson Portable Electrometer.** *Exhibited by* J. White.

129 **Well Thermometer,** in copper case. *Exhibited by* L. P. Casella, F.R.Met.Soc.

130 **Thermometer as used on board Ship,** for taking the temperature of the sea. *Exhibited by* The Meteorological Council.

131 **Miller-Casella Deep-sea Thermometer.** *Exhibited by* L. P. Casella, F.R.Met.Soc.

132 **Negretti and Zambra's Recording Deep-sea Thermometer.**—This consists of a turnover thermometer which has its bulb protected by an outer cylinder. The thermometer is attached to a frame with a vertical propeller. In its descent through the water the propeller is lifted out of gear and revolves freely on its axis ; but as soon as the apparatus is pulled up towards the surface the propeller falls into gear and revolves in the contrary direction, turning the thermometer over once, and then becoming locked and immovable, thus records the temperature at that depth. *Exhibited by* Messrs. Negretti & Zambra.

133 **Negretti and Zambra's Marine Thermometer for Shallow Depths.**—A turnover thermometer is fitted into a wooden frame loaded with shot free to move from end to end of it, and heavy enough to render the instrument just buoyant in sea water. *Exhibited by* Messrs. Negretti & Zambra.

134 **Magnaghi's Frame for Negretti and Zambra's Reversing Thermometer.**—The reversing gear is a fan actuated by the current of water in raising the instrument. *Exhibited by* Messrs. Negretti & Zambra.

135 **Earth Thermometers constructed for the Underground Temperature Committee of the British Association.**

1. Slow action thermometer. Bulb of thick glass surrounded by stearine. Enclosed in outer tube for convenience. For use in holes drilled in sides of workings.

2 and 3. Maximum thermometers protected from pressure by a sealed outer tube. For use in deep wells and borings. No. 2 (on Phillips's principle) has a very fine bore, for stability against jolts, and is used upright, bulb down. No. 3 (on Negretti's principle) is used bulb up.

Exhibited by Prof. J. D. Everett, F.R.S.

136 **Symons' Earth Thermometer.**—This consists of a sluggish thermometer mounted in a short-weighted stick attached to a chain, and an iron pipe which is drawn out at the bottom to a point for driving into the earth. *Exhibited by* L. P. Casella, F.R.Met.Soc.

137 **Earth Thermometer, with Slow Action Thermometer.** *Exhibited by* Messrs. Negretti & Zambra.

138 **Deep Earth Thermometer** as used at Harestock, Winchester. This case with its thermometer (the cylindrical bulb of which rests about half an inch above the perforated plug at its lower extremity), is fitted to travel to its position in the soil in a square-sided tube of teak wood, which stands 4 inches above the surface of the ground, to prevent water flowing into it, and extends perpendicularly into the earth as far as the square portion of the thermometer case. The cylindrical portion of the

latter passes below the teak tube into a hole, in which it exactly fits, and thus the thermometer acquires the true temperature at which it rests in the soil. When raised to the surface to be read the portion below the shutter remains in the teak tube, the brush and fur trimmings prevent air currents in the tube. For the same purpose plugs and cotton waste fill the upper end of the tube, which are removed before raising the thermometer by its brass chain, which passes over a wheel on a post. This chain should have a mark on it to show when the thermometer case is about to touch the bottom of the hole. Also the top of the tube is covered with a wooden box having a sloping top, and this is covered with a waterproof apron of painted canvas to keep out wet. *Exhibited by* COL. H. S. KNIGHT, F.R.Met.Soc.

139 **Richard's Alarm Thermometer.**—This consists of a flat but slightly curved tube filled with liquid, the bottom end of which is fixed. To the upper end is attached a rod which moves an index hand in front of a dial, thus indicating the temperature. There are also two adjustable indices which can be set to any desired temperatures, so that when the indicating hand touches these, electric contact is made and a bell set ringing. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

140 **Alarm Thermometers**, with movable indices, which can be set to give an alarm at any required temperature.
Exhibited by J. J. HICKS, F.R.Met.Soc.

141 **Pickering's Evaporimeter.**—The moist surface consists of a sheet of blotting-paper held vertically by means of a movable copper frame in a vessel of water fitted with a graduated glass side tube. The sheet of blotting-paper ends in a tongue, which dips into the water, and is thus kept moist. The graduations are such that they give the number of units of volume evaporated per unit area of paper exposed.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

142 **Richard's Self-recording Evaporation Gauge.**—The water contained in a closed reservoir is aspired by a wick which is continually wetting a sheet of blotting-paper of a determined section and submitted to evaporation. A float transmits to the pen the height of the liquid.
Exhibited by Messrs. J. LEVI & Co.

143 **Leslie's Ætherioscope.**—This consists of two glass bulbs united by a vertical glass tube, of so fine a bore that a little coloured liquid is supported in it by its own adhesion, air being confined in each of the bulbs. The lower bulb is enclosed in a highly polished brass sphere. The upper bulb is blackened, and placed in the centre of a metallic cup, which is gilt on the inside, and may be covered by a top. When the top is on, the liquid remains at the zero of the scale. On removing the top and presenting the instrument to a clear sky, either by night or by day, the upper bulb is cooled by terrestrial radiation, while the lower bulb retains the temperature of the air. The air confined in the upper bulb therefore contracts, and the elasticity of that in the lower bulb forces the liquid up the tube to a height proportionate to the intensity of the radiation.
Exhibited by Messrs. NEGRETTI & ZAMBRA.

144 **Hypsometer, for measuring Mountain Heights by the Temperature of the Vapour of Boiling Water.**
Exhibited by L. P. CASELLA, F.R.Met.Soc.

145 **Pocket Boiling-point Apparatus.**
Exhibited by Messrs. NEGRETTI & ZAMBRA.

CHARTS AND PHOTOGRAPHS.

146 **Specimens of the Daily Weather Charts** issued by the following Governments :—Algeria, Austria, Bavaria, Belgium, France, Germany, Great Britain, Greece, India, Italy, Japan, New South Wales, Portugal, Queensland, Roumania, Russia, Spain, Switzerland, and the United States of America. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY and by THE METEOROLOGICAL COUNCIL.

147 **Specimens of the Daily Weather Report,** giving copies of the first Report issued in February 1860, and the Report now being issued by the Meteorological Office. *Exhibited by* THE METEOROLOGICAL COUNCIL.

148 **Specimens of the Weekly Weather Report,** the copies being that of No. 1, issued February 1878, and that now being issued by the Meteorological Office. *Exhibited by* THE METEOROLOGICAL COUNCIL.

149 **Set of Meteorological Curves having reference to the Gale of March 3, 1897,** comprising—

1. For Falmouth. Barograms, Thermogram, Anemograms, and Rainfall Curves.
2. For the Scilly Islands. Pressure Tube Anemograms, and Aneroidogram.
3. For London. Aneroidogram with very open scale.
4. Two Weather Charts showing the systems prevailing over the British Islands at 8 a.m. on March 3 and 4.

Exhibited by THE METEOROLOGICAL COUNCIL.

150 **Records from the Dines and Robinson Anemographs at the Rousdon Observatory, Devon,** during the gale of March 3, 1897. *Exhibited by* C. E. PEEK, F.R.Met.Soc.

151 **Charts showing the Distribution of Temperature over the British Islands** as follows :—

(*a*) Mean Daily Minimum. (*b*) Mean Daily Maximum. (*c*) Mean Daily Average. For the Twenty-five years, 1871-1895, for the months of January and July.

Exhibited by THE METEOROLOGICAL COUNCIL.

152 **Model of Signal Station, showing Cone used for Storm Warnings.** *Exhibited by* THE METEOROLOGICAL COUNCIL.

153 **Charts from Casella's Altazimuth Anemometer,** showing the vertical angle as well as the horizontal direction and force of the wind. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

154 **Barograms from Richard's Self-recording Aneroid,** showing records for four successive years by means of different coloured inks. *Exhibited by* Dr. J. L. GREEN, F.R.Met.Soc.

155 **Photographs, Drawings, and Charts, illustrating the use of Kites** for obtaining meteorological records in the free air. *Exhibited by* A. L. ROTCH, F.R.Met.Soc.

156 **Photograph showing the fixing of a 70-ft. Earth Thermometer** at Col. Knight's Observatory, Harestock, Winchester. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

157 **Photograph of the Instruments for the Determination of the Temperature of the Platinum Underground Thermometers** at the Radcliffe Observatory, Oxford. *Exhibited by* E. J. STONE, F.R.S.

158 **Views of the Royal Observatory, Greenwich.**

1. Greenwich Castle on the foundations of which the Observatory was built.
2. Observatory as in the time of Flamstead.
3. Observatory as in 1841. *Exhibited by* W. ELLIS, F.R.S.

159 **Photographs of Thermograph** in use at the Royal Observatory, Greenwich. *Exhibited by* W. ELLIS, F.R.S.

160 **View of Osler's Anemometer** at the Royal Observatory, Greenwich. *Exhibited by* W. ELLIS, F.R.S.

161 **Illustration of Thomson's Electrograph,** as fitted at the Coats' Observatory, Paisley. *Exhibited by* J. WHITE.

162 **Photographs explanatory of the Method of Measuring Cloud Altitudes** in use at Exeter. *Exhibited by* A. W. CLAYDEN, F.R.Met.Soc.

163 **International Cloud Atlas.**—Pictures illustrating the various forms of Cloud included in the International Cloud Nomenclature. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

164 **Photographs of Clouds** taken at Sydney Observatory, New South Wales, by Mr. H. C. RUSSELL, F.R.S. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

165 **Photographs of Waterspout** in Vineyard Sound, Mass., U.S.A., August 19, 1896. (4 Photos.) *Exhibited by* H. P. CURTIS, F.R.Met.Soc.

166 **Photograph of Section of Iron Roofing** at Waireka, New South Wales, punctured by hailstones, January 5, 1896. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

167 **Photographs of Flashes of Lightning.** *Exhibited by* J. LEADBEATER.

168 **Photographs of Oak Tree struck by Lightning.** *Exhibited by* J. LEADBEATER.

169 **The Frozen Thames, February 1895,** consisting of five views between the Tower and Westminster Bridges taken by Mr. Birt Acres, F.R.Met.Soc. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

170 **Ice on the Thames off Charlton, February 1895.** *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

171 **Photographs of Ice on Lake Windermere, February 1895.** (4 Photos.) *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

172 **Photograph of Snowdrifts** in Parliament Street, Ramsey, Isle of Man, February 11, 1895. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

173 **Frame of Photographs of Ice Crystals on Window Panes.** *Exhibited by* J. LEADBEATER.

174 **Dr. G. Hellmann's book "Schneekrystalle."** *Exhibited by* Herr R. MÜCKENBERGER.

175 **Photograph of International Meteorological Conference** held at Paris, September 1896. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

176 **Photograph of Members of the International Meteorological Conference** at M. Teisserenc de Bort's Observatory at Trappes, Seine-et-Oise, France, September 21, 1896. *Exhibited by* THE ROYAL METEOROLOGICAL SOCIETY.

177 **Portrait of Luke Howard, F.R.S.** Born November 28, 1772; died March 21, 1864. Drawn by Bedford, about 1843. *Exhibited by* W. D. HOWARD, F.R.Met.Soc.

178 **Photographs of Clouds.** *Exhibited by* A. W. CLAYDEN, F.R.Met.Soc.

179 **Photographs of Thermometer Screen** as arranged by Col. Knight, at Harestock, Winchester. *Exhibited by* Col. H. S. KNIGHT, F.R.Met.Soc.

EXPERIMENT.

180 **Experiment illustrating the Formation of the Tornado Cloud.** (Demonstrations at frequent intervals.) *Exhibited by* W. H. DINES, F.R.Met.Soc.

THE RELATION BETWEEN COLD PERIODS AND HIGH BAROMETRIC CONDITIONS OF WEATHER IN ENGLAND DURING THE WINTER.

By W. H. DINES, B.A., F.R.Met.Soc.

[Read April 21, 1897.]

THERE seems to be a generally accepted belief that a high barometer during the winter is likely to be accompanied by exceptional cold, but in so far as England is concerned my observation has led me to the opposite conclusion, and I always expect a frost to break up as soon as the barometer gets much above 30·00 ins. To test the truth of the theory I have tabulated the height of the barometer during all the cold periods that occurred during the three winter months of the fifty years 1841-90 inclusive.

In questions of this kind it is necessary to define exactly the meaning of the terms employed. Probably a "cold period" would mean to most people a period during which snow lay on the ground, or skating was possible, and not merely a time during which the temperature was 1° or 2° below the mean. In the accompanying table it has been defined as follows:—

The first day is the first of three consecutive days, each having a mean temperature equal to or below 32°. The last day is—*Firstly*, the day preceding a day of mean temperature equal to or exceeding 40°. *Secondly*, the day preceding a temperature equal to or exceeding 35°, where a period of three consecutive days has a mean equal to or exceeding 35°.

Thus, it has been considered that one daily mean exceeding 40°, or a period of three consecutive days with a three days' mean exceeding 35°, has broken up the cold period. Doubtless, the exact way in which the period may be defined is immaterial, but some fixed rule is absolutely necessary. The temperature and the barometric heights have been taken from the Greenwich records.

DATE OF PERIOD.	No. of days.	Average height in inches of the barometer reduced to sea-level.			
		Below 29.8.	29.8—30.0.	30.0—30.2.	Above 30.2.
1841. Jan. 4—15 . .	12	29·50	...	...	...
1841. Dec. 18—21 . .	4	29·52	...	...	...
1842. Jan. 3—24 . .	22	...	29·97	...	...
1843. Feb. 14—19 . .	6	...	26·96	...	...
1844. Dec. 5—15 . .	11	...	...	30·02	...
1844. Dec. 22—27 . .	6	...	...	30·19	...
1845. Jan. 29—Feb. 2 .	5	29·46	...	...	...
1845. Feb. 7—13 . .	7	...	...	30·00	...
1845. Feb. 19—22 . .	4	...	29·95	...	...
1846. Dec. 11—18 . .	8	29·73	...	...	...
1846. Dec. 25—Jan. 3 .	10	...	...	...	30·42
1847. Jan. 10—23 . .	14	...	...	30·02	...

DATE OF PERIOD.	No. of days.	Average height in inches of the barometer reduced to sea-level.			
		Below 29.8.	29.8—30.0.	30.0—30.2.	Above 30.2.
1847. Feb. 8—13	6	26·71	...	...	...
1848. Jan. 20—29	10	...	...	30·12	...
1849. Jan. 1— 8	8	...	29·94	...	...
1850. Jan. 7—18	12	...	29·90	...	...
1853. Feb. 12—24	13	29·76	...	...	...
1853. Dec. 15—Jan. 6	23	29·68	...	...	...
1855. Jan. 17—Feb. 24	39	29·78	...	...	...
1855. Dec. 11—13	3	...	29·97	...	...
1855. Dec. 19—22	4	...	29·93	...	...
1856. Jan. 11—15	5	...	...	...	30·25
1856. Jan. 19—Feb. 3	16	...	29·93	...	...
1856. Dec. 25—29	5	29·36	...	...	...
1857. Jan. 27—Feb. 5	10	...	29·89	...	...
1858. Jan. 4— 7	4	...	...	...	30·32
1858. Jan. 24—26	3	...	...	...	30·39
1858. Feb. 18—28	11	...	29·96	...	...
1859. Dec. 14—20	7	...	29·82	...	...
1860. Feb. 10—15	6	...	...	...	30·30
1860. Dec. 18—29	12	29·70	...	...	...
1861. Jan. 2—19	18	...	...	30·15	...
1862. Jan. 17—21	5	...	29·86	...	...
1864. Jan. 2— 9	8	...	...	...	30·30
1864. Feb. 6—11	6	29·77	...	...	...
1864. Feb. 21—25	5	...	29·96	...	...
1865. Jan. 21—29	9	29·61	...	...	...
1866. Dec. 31—Jan. 5	6	29·60	...	...	...
1867. Jan. 12—22	11	29·77	...	...	...
1867. Dec. 31—Jan. 11	12	...	...	30·17	...
1869. Dec. 1— 5	5	...	...	30·07	...
1869. Dec. 25—29	5	...	29·82	...	...
1870. Jan. 26—29	4	...	...	...	30·23
1870. Feb. 9—19	11	...	...	30·09	...
1870. Dec. 21—Jan. 5	16	...	29·95	...	...
1871. Jan. 10—13	4	...	29·94	...	...
1871. Jan. 25—Feb. 2	9	...	29·87	...	...
1871. Dec. 7— 9	3	...	...	...	30·27
1873. Dec. 9—11	3	...	...	...	30·57
1874. Feb. 9—11	3	...	...	...	30·40
1874. Dec. 15—Jan. 1	18	...	...	30·03	...
1875. Dec. 1—10	10	...	29·99	...	...
1876. Jan. 6—16	11	...	...	...	30·29
1876. Feb. 10—13	4	29·79	...	...	...
1878. Dec. 9—25	17	29·69	...	...	...
1879. Jan. 5—12	8	29·72	...	...	...
1879. Jan. 19—Feb. 5	18	...	...	30·07	...
1879. Dec. 1—13	13	...	...	30·12	...
1880. Jan. 18—29	12	...	...	...	30·28
1881. Jan. 12—26	15	29·79	...	...	...
1882. Dec. 10—12	3	29·73	...	...	...
1885. Jan. 21—25	5	...	...	30·04	...
1885. Dec. 8—11	4	...	...	...	30·28
1886. Jan. 7—10	4	...	29·87	...	...
1886. Feb. 7—11	5	...	...	...	30·47
1886. Dec. 18—22	5	...	29·92	...	...
1886. Dec. 31—Jan. 10	11	29·51	...	...	...
1887. Jan. 13—17	5	...	...	30·16	...
1887. Dec. 26—Jan. 1	7	...	...	30·04	...
1888. Feb. 22—29	8	...	...	30·07	...
1889. Jan. 4— 7	4	...	...	...	30·27
1889. Feb. 10—13	4	...	29·81	...	...
1889. Dec. 1— 8	8	...	...	...	30·28
1890. Dec. 10—31	22	...	...	30·06	...

If we divide these 74 frosts into 4 sets, namely:—

(1) Those with pressure below 29·80 ins.
(2) Those with pressure between 29·80 ins. and 30·00 ins.
(3) „ „ 30·00 ins. and 30·20 ins.
(4) Those with pressure above 30·20 ins.

we find 216 days of frost in set (1).
173 „ „ (2).
190 „ „ (3).
93 „ „ (4).

From the table we obtain the following particulars:—Out of a total of 74 frosts, 16 only had a pressure exceeding 30·20 ins., and the majority of these 16 were of very short duration. Thirty-three, or less than half, had a pressure exceeding 30·00 ins. Twenty had a pressure below 29·80 ins., and these 20 include almost every frost in the period remarkable for its length or severity.

Hence it is perfectly clear that in the south-east of England frost is not usually accompanied by a high barometer. It is interesting to note in passing that the average number of days of duration of frost is only 13, and that the longest consecutive period shown above is 39 days, occurring in 1855.

England being a small island, and surrounded by comparatively warm water, it is essential for cold weather, as a general rule, that cold air should be brought from colder parts, and the calms and light airs of an anticyclone do not permit this condition to be complied with. Neither can the descending air of an anticyclone be cold, for the warming, due to increase of pressure, is certainly greater than the original coldness due to increased altitude. From a large number of observations, made both from balloons and at mountain observatories, it is known that the average decrease of temperature as we ascend is about 1° for 300 feet. But it is a fact, established by many carefully conducted experiments, that when air comes under the increased pressure due to a fall of about 190 feet it is thereby warmed 1°, and inasmuch as this may be found stated in any good text-book on Heat, we may accept it as altogether beyond dispute. Thus a descending current of air cannot reach the earth as a cold current, unless its initial temperature at starting be as low as the temperature found by deducting 1° from the temperature at the earth's surface for every 190 feet of altitude from which it commenced its downward movement. This condition we know does not hold, for in anticyclonic weather the decrease of temperature is below the normal rate of 1° for 300 feet. In fact during calm weather the air is often warmer at an elevation of 500 to 1000 feet than it is on the ground. It is stated that on the Continent cold and anticyclonic conditions prevail together, but I am inclined to doubt whether the statement is truer there than it is here. Still the conditions are very different. In England, however light the wind, it is probable that the air passing over any part has left the sea within a period of 24 hours. If any persons doubt this I would ask them whether they would be willing, choosing their own time, to go up in a free balloon with the certainty that they could not descend for at least 24 hours. Hence even in the calmest weather there is no time for any large mass of air to be greatly chilled by radiation, since this method of cooling can only occur over a land area. If the air does not reach England cold, it cannot become so while it is here. On the Continent, and more particularly in the more enclosed valleys of the Alps, a surface layer of extremely cold air may accumulate, and remain comparatively undisturbed for days. But even there the effect on the winter temperature is not a very important one, for if we compare the temperature with that of Asia, and of the eastern part of North America, in the same latitude, we find Central Europe to be from 30° to 40° warmer, the warming effect of the prevailing Westerly winds being felt for a great distance from the Atlantic, whence these winds come.

It must be confessed that we are very ignorant of the cause of winter changes of temperature. The direction of the wind is an important, but I doubt whether it be the most important, element. In some winters a change of wind to North-east is followed instantly by frost; in others the wind may be North-east for a fortnight and the temperature hardly reach the freezing-point, even at night. Sometimes, too, a thaw may occur with a North-east wind. I believe that our temperature depends very largely on that of the upper layers of air, and that a shift to a more Northerly point, or perhaps even a slackening in the strength of the Westerly upper current, may produce more change of temperature than an absolute reversal of the direction of the surface wind. It is certain that, allowing for the adiabatic change of temperature due to change of pressure, roughly 1° for every 200 feet, warm air cannot lie under cold air, but there is no apparent reason why the air should not be cold below and comparatively warm above.

The fact that belief in an untrue or doubtful theory (as this supposed connection between cold and a high barometer seems to me to be) tends to retard the advance of any science, must be my excuse for bringing this subject to the notice of the Fellows of the Royal Meteorological Society.

DISCUSSION.

The President (Mr. E. Mawley) said that the Fellows were indebted to Mr. Dines for the paper, which, although a very short one, was much to the point, and must have entailed considerable research in its preparation. The conclusions at which the author had arrived were certainly in opposition to those which had been generally accepted. Whether the actual height of the barometer be a reliable guide as to the amount of frost or not, the table he had given clearly showed that a frosty period rarely occurred with a barometric pressure below 29·5 ins., for there were in it only two instances of lower mean readings, and then the frost on each occasion lasted only five days. Setting aside entirely the question discussed by Mr. Dines, there could not be a doubt but that the movements of the barometer during the winter months afforded valuable indications of coming changes in temperature, a rising barometer almost invariably showing the approach of colder weather, and a falling one that of milder conditions than those which had previously prevailed.

Mr. F. **Gaster** said that the height of the barometer at any single station did not prove the prevalence of anticyclonic conditions. The barometric pressure at a certain station might be fairly high and yet be under the influence of cyclonic circulation. The *Weather Charts* prior to 1870 were so scanty, and those of so limited an area, that he would not discuss any instances given by Mr. Dines before that date, but he had referred to some of the later periods quoted by Mr. Dines, and in several cases had found that they could not be said to have occurred under truly anticyclonic conditions. For instance, in the frost from December 7-9, 1871, the barometric pressure in London was 30·3 ins. and the temperature 26°, yet the distribution of pressure over Scotland was cyclonic with a North-westerly wind, and the temperature at Nairn was 10° higher than that of London. A frost period in which anticyclonic conditions clearly prevailed was that of January 18-29, 1880. The mean barometric pressure for the period being 30·28 ins. A temperature of 14° was registered both at Loughborough and at London, a Westerly wind blowing at the time. Most people remembered the frost period of January 1881, during which occurred the heavy snowstorm of the 18th. On the 13th of that month an anticyclone covered Ireland, the temperature at Parsonstown being 17°, which was much lower than in England. In London, which was slightly under cyclonic influence, the temperature was 24°. On the 17th, when an anticyclone covered the kingdom, the thermometer fell, and temperatures of from 4° to 12° were registered at the inland stations of England, and from 22° to 27° in Scotland. On the following day, the 18th, came the snow. A cyclone had advanced from Spain and dispersed the previously prevailing conditions, causing a sudden rise of temperature of 20°, so that really "Black Tuesday" was not so cold as people believed. In the rear of the storm was another system of high pressure, and on the following day the temperature fell 14°. He had known a small depression pass across Ireland at a time when very low temperatures were being registered, the effect of which was to produce temporarily warmer weather; but as soon as the disturbance had passed away the temperature fell to its former reading. He had also known a high pressure system, even after passing over the warm waters of the Atlantic, have a cooling effect on the temperature. He was not prepared to say there were not both warm and cold anticyclones. The original idea was that the descending current in an anticyclone produced the cold, but this theory had given way to the much more feasible one, of radiation of heat produced by the clear skies. As a rule, the characteristics of an anticyclone were a steady barometer and a small amount of cloud; but when the barometric pressure is irregular with steep gradients, strong winds and cloudy skies, checking radiation, then it is that the anticyclone is accompanied by warm weather. Mr. Gaster also said that in the Preface to the *Quarterly Weather Report* for 1880 there was a diagram showing the differences between cyclonic and anticyclonic conditions.

Mr. C. **Harding** said that taking the periods given by Mr. Dines, 27 out of the 74 would be found to have occurred with the barometric pressure below 29·9 ins., which was a fairly average atmospheric condition. He endorsed all that Mr. Gaster had said concerning the paper. He could not agree to the statement made by Mr. Dines in the first paragraph to the effect that he (Mr. Dines) always expected a frost to break up as soon as the barometer rose much above 30·00 ins. It was also mentioned in the paper that the longest period of frost was in 1855, when it occurred on 39 consecutive days; but this was eclipsed by that of 1890-1, discussed by himself, which was of 43 days' duration.

Mr. F. J. **Brodie**, while agreeing with much that had been said by Mr. Gaster and Mr. C. Harding, was of opinion that there was a considerable element of truth in the theory advanced in the paper. As a general rule, an anticyclone was doubtless accompanied in the winter time by cold weather, but there were many exceptions to this; and, on the other hand, plenty of cases might be cited in which severe frosts had occurred with a purely cyclonic distribution of pressure. He was prepared to agree in a large measure with the criticism that the height of the barometer in one spot gave no certain indication as to whether the conditions were cyclonic or anticyclonic; but at the same time, the evidence on these points is fairly conclusive in cases when the reading of the barometer happened to be very low or very high. Rather more than a year ago, he drew the attention of the Society to the fact that many of our largest and most important anticyclones were accompanied in winter by temperatures little, if any, below the normal. This seemed especially the case when the barometer reached an unusual height, as, for instance, in the remarkable anticyclones of January 1882 and January 1896.

Mr. W. H. Dines said, in reply, that he quite agreed with Mr. Gaster and Mr. Harding as to the impossibility of determining from one station only whether the conditions were cyclonic or otherwise, but he had consulted several Fellows of the Society on this point, and all had told him that they thought it a very unusual thing for anticyclonic conditions to occur with a barometer below 30·00 ins., in fact most had said that it was improbable with a lower pressure than 30·20 ins. Hence it was unlikely that the majority of the frosts given in the table had occurred during the prevalence of an anticyclone. In fact the argument acts both ways, for it is quite possible that some of those with a pressure over 30·20 ins. were not accompanied by anticyclonic conditions. Mr. Gaster had cited instances of extreme cold occurring with a high barometer, and of a rise of temperature accompanying a falling barometer. No doubt such instances were numerous, and he (Mr. Dines) had no wish to assert that they were not; he only wished to protest against the theory that warmth and cyclonic conditions, and cold and anticyclonic conditions, were in the winter necessarily coincident. In cold weather a rise of temperature would naturally accompany the passing of a depression, on account of the mixing of various layers of air, for extreme cold only occurred on clear, calm nights, and was confined to the lowest layers. Mr. Harding had surmised rightly in suggesting that he had purposely refrained from defining an anticyclone. Since asked, however, he would say that he considered an anticyclonic area to be one in which the barometer was higher than in surrounding districts, and he would limit the region to those parts in which the air was, on the whole, descending from higher levels. The definition was useless for the purposes of his paper, and probably no two persons would agree as to the precise position of the boundary line on any given chart. It was not unlikely that he was inclined to restrict the area too much; he had thought a breeze exceeding about force 4 was incompatible with an anticyclone, but from Mr. Gaster's definition this did not seem to be the case. Inasmuch as it appeared from the table that only about one day's frost in seven was accompanied by a pressure exceeding 30·20 ins. he could not understand Mr. Harding's objection to his statement that a frost was likely to break up if the barometer were high. He fully agreed with Mr. Brodie as to the number of exceptions, but he did not think in this case that they proved the rule.

SUGGESTIONS OF SUNSPOT INFLUENCE ON THE WEATHER OF WESTERN EUROPE.

By ALEXANDER B. MacDOWALL, M.A., F.R.Met.Soc.

[Read April 21, 1897.]

NOTWITHSTANDING all that has been written about the influence of sunspots on weather (and it is not a little), it must be confessed that the matter is not yet satisfactorily elucidated. Some competent meteorologists doubt whether the sunspot cycle affects weather at all. There are dogmatists who maintain that there is, and can be, no such influence, and that it is "beneath the dignity of science" to give attention to the subject. With these we have not here to do. Most of us, I take it, keep an open mind, and are even ready to think it likely that those tremendous periodical upheavals in the sun, giving spots that are sometimes even visible to the naked eye, do in some way (on which we shall by and by have more light) affect the atmospheric ocean.

But the evidence hitherto adduced obviously "leaves much to be desired." It is at various points defective and conflicting. Correspondences with the sunspot cycle observed through a long series of years have at length failed; correspondences noticed in one region are not noticed in another, or the correspondence in one region appears even to be opposite to that in another. The relation, if it exist, is evidently a complex one. Yet we may, I think, at least agree with the view which I find expressed lately by an eminent American meteorologist, that the points of coincidence that have been established are too numerous to be lightly put aside.

In many of the researches hitherto described, the year has been considered as a whole, the annual mean temperature or other item being studied. It seems to me a more fruitful and promising method to compare corresponding portions of successive years; the winter half, the summer half, the four seasons, the quarters, etc., even the months separately. In the present paper I would invite attention to the results of some inquiries conducted on this principle. The weather effects specified appear to me suggestive of a relation to the sunspot cycle. But, in any case, a fresh discussion of the subject in view of the facts brought forward may perhaps not be unprofitable.

In making out curves of various weather elements, I have used smoothing methods freely, sometimes smoothing with *averages* of five, sometimes with *additions* of five, but I do not confine myself to these methods.

In the diagram (p. 244) will be found first (*a*) an inverted curve of sunspots since 1829; then next, below it (*bb'*), the first curves we have to consider. The dotted one represents the average mean temperature of June at three European stations, viz. Bremen, Paris, and Geneva, since 1829, and the continuous one shows the result of smoothing with averages of five. The eye readily makes out in the smoothed curve six irregular waves corresponding more or less closely with the six waves of the sunspot cycle; the maxima of temperature coming, on the whole, near minima of sunspots, and the minima of temperature near maxima of sunspots.

Merely remarking here that a smoothed curve of June temperature at Greenwich is very similar in character to that just given, let us now

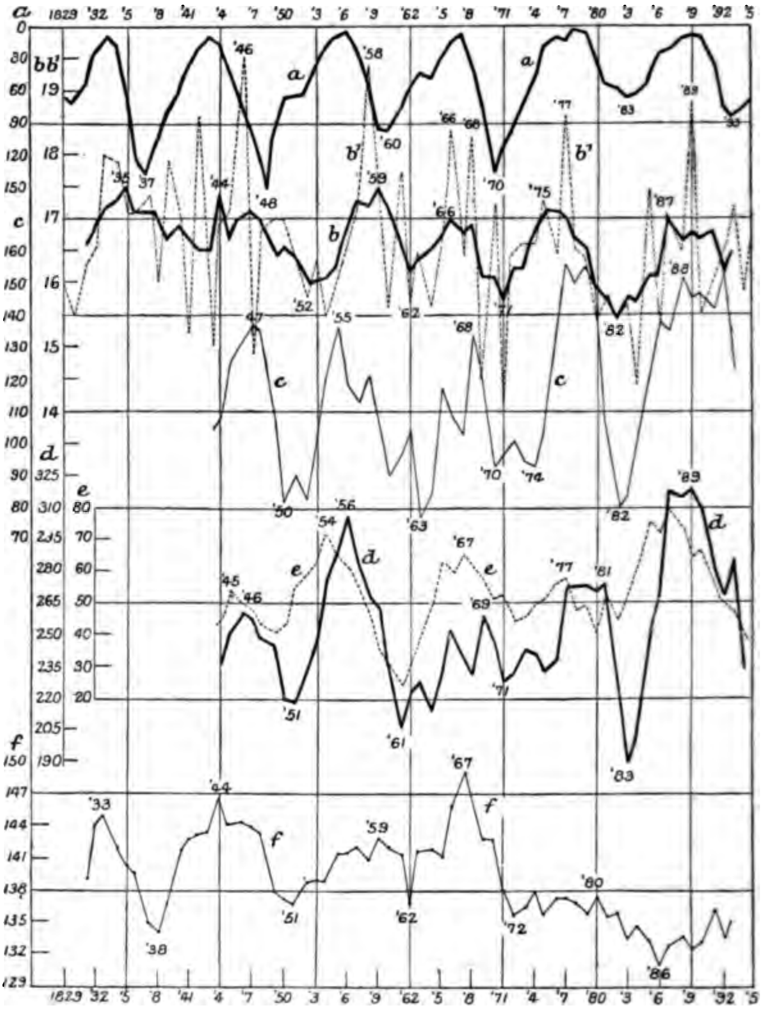


FIG. 1.

turn to consider the number of frost days at Greenwich in the months of December and January following. A curve (*c*) of this item, smoothed with additions of five, is given in the diagram (each group being here designated by the *earlier* year, *e.g.* 1857 means December 1857 to January 1858). Here again we find a good deal of correspondence with the sunspot curve, maxima of the frost curve coming near minima of sunspots, and minima of the former near maxima of the latter.

A comparison may here be made as follows:—Take the following five items, viz. the maximum sunspot year, one year before, and three years after; then indicate in each of these, by a plus or minus sign, whether the number of frost days in December to January is above or below the average (viz. 23). Also add the number of frost days in each group. Then we have—

Sunspot Max.	Year group.	Max.	Frost days in group.
1848	1847-51	+ − + − −	107
1860	1859-63	− + − − −	98
1870	1869-73	av + − − −	99
1883	1882-86	− − − + +	103
1893	1892-96	+ − + −	(91)
		Average (of four)	102

Here we find 15 minus, 8 plus, and one average; and the average number in those four completed groups is 102 (the numbers ranging from 98 to 107). Dealing similarly with sunspot minima, we have—

Sunspot Max.	Year group.	Min.	Frost days in group.
1843	1842-46	− − + − +	108
1856	1855-59	+ + − − −	113
1867	1866-70	+ + − av +	134
1878	1877-81	− + + + −	155
1889	1888-92	av − + + +	147
		Average	131

The preponderance of plus signs is not here so marked,[1] 13 against 10 (with two cases of average). The average of the five groups is 131, with a range from 108 to 155. It will be observed that the highest number of the maximum groups (107) is under the lowest of the minimum groups (108).

These facts, then, appear to indicate a tendency on the one hand to more heat in June, and on the other to more cold in December to January near minimum sunspots; and to less heat in June and less cold in December to January near maximum sunspots.

Now these are but small portions of the year, and we may, I think, go further. If we make out a number of these smoothed curves relating to heat and cold, taking various sections of the year, and different European stations, certain common tendencies more or less pronounced, may be made out. Such a tendency may be evident at two stations, but more pronounced at one than another; and it may be evident through a long portion of the period considered, and become obscured at some point or other. The fact I wish to emphasise is, that in the warmer portion of the year the tendency is generally to greater *heat* near minimum sunspots, and in the colder part to greater *cold* near minimum sunspots. It is only a tendency, an average effect, and those who look for more will be disappointed. The question is, are we entitled to look for more? In illustration of this may be given a smoothed curve (averages of five) of the mean temperature of April to September at Bremen (*f*),[2] which appears to be of the same order as the June curve above. In the curves for Paris and Greenwich, a like tendency may be perceived, I think, but less pronounced. On the other hand, various combinations of the months containing frost days at Greenwich will be found to show a common tendency very well. We have already given December to January. Here is a smoothed curve (*d*) of frost days in November to March (each group designated by the later year), and another (*e*) for March alone. All three frost curves may be said to have a family likeness. We might have included a curve of frost days in the first quarter, and one of the total number in the year.

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[1] A better result is obtained if we take as centre of our five-year groups the year just *before* each minimum, instead of the year just *after*; we have then 16 plus and 9 minus.

[2] This curve has previously appeared in *Nature*, vol. 54, p. 572.

We may here make another comparison like the one above, taking the total number of days of frost in the year.

Sunspot Max.	Year Groups.	Max.	Frost days in groups.
1848	1847-51	+ − − − −	263
1860	1859-63	− + − − −	231
1870	1869-73	− + + − −	258
1883	1882-86	− − − + +	238
1893	1892-96	+ − − +	(228)
		Average (of four)	247

Here we have 16 minus and 8 plus (the former double the latter). The group numbers range from 231 to 263, with an average of 247.[1]

Sunspot Min.	Year Groups.	Min.	Frost days in groups.
1843	1842-46	− − + + −	266
1856	1855-59	+ + − + −	331
1867	1866-70	− + − − +	279
1878	1877-81	− + + − +	308
1889	1888-92	+ + + + +	344
		Average	306

Here we have 15 plus and 10 minus, or, if we exclude the two outer columns, 10 plus and 5 minus. The group numbers range from 266 to 344, with an average of 306.

We have thus far looked at the evidence of two opposite tendencies, in the two halves of the year, both showing a relation to the sunspot cycle.

It may now be appropriate to ask: Does the difference in mean temperature of the two halves, April to September and October to March, reveal any relation to the same cycle? Calculating this difference in the case of Greenwich,, *i.e.* the temperature difference between each summer half and the winter half following, and plotting the series as a curve, we have in Fig. 2 the dotted curve (*g*), and this has been smoothed with averages of five (*g'*). The five waves of this smoothed curve show a fair correspondence with the sunspot curve, the maxima of the former

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[1] Comparisons of this kind might, perhaps, be found to afford a clue to future weather. Thus, it is required in the above table to fill in the sign for 1896 (say) before that year has begun. The probability of a *minus* seems strong. For, first, in all the other groups the minus signs preponderate, and a minus is required to give a preponderance here. Second, the four years 1892-95 give a total of 228 frost days; and the difference between this and 263, the highest number in previous five-year groups, is 35, while the yearly average of frost days is 56. We now know (Dec.) that the total for 1896 will prove to be very small.

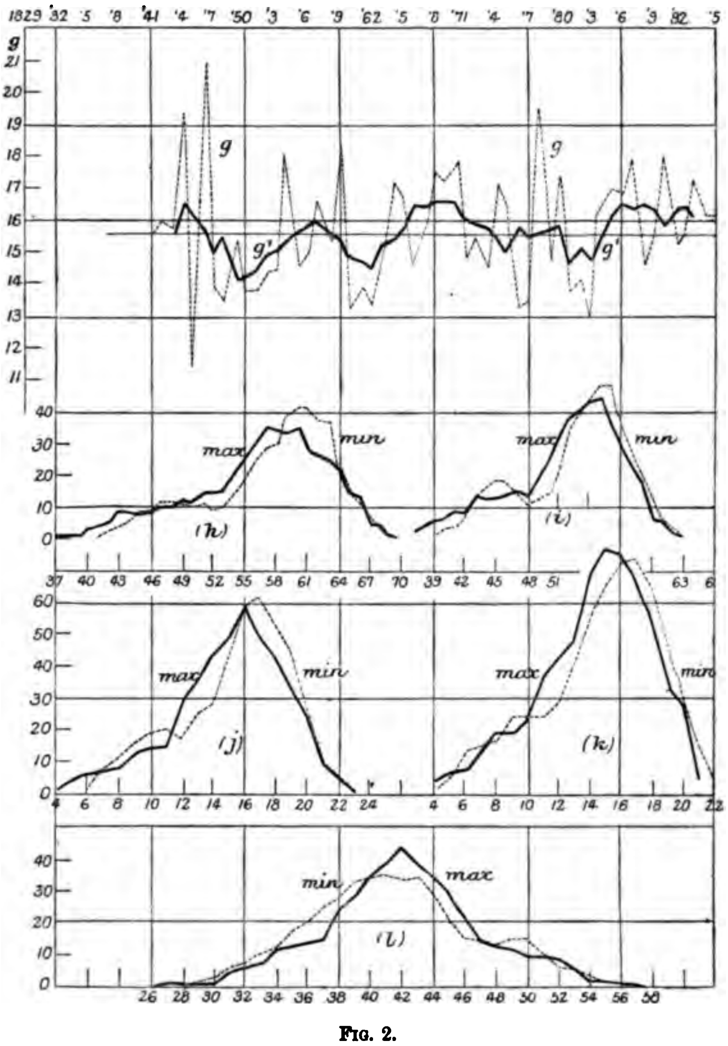

FIG. 2.

corresponding with the minima of the latter, and *vice versâ.* The following data may be tabulated for consideration:—

Sunspot Min.	Year Groups.		Average of Group.
			°
1843	1844-46	+ − +	17·1
1856	1857-59	+ − +	16·7
1867	1868-70	+ + +	17·5
1878	1878-80	+ − +	17·2
1889	1889-91	− + −	16·2
			Average 16·9

That is, 10 plus, 5 minus, the average of the groups being 16°·9.

Sunspot Max.	Year Groups.		Average of Group.
			°
1848	1848-50	- - -	14·2
1860	1860-62	- - -	13·5
1870	1871-73	- - -	14·9
1883	1882-84	- - +	14·5
1893	1891-93	- av +	16·0
		Average	14·6

Here we have 12 minus, 2 plus, and 1 average, the average of the groups being 14°·6. It will be observed that the selection of three-year groups is not in this case quite uniform in principle. Still the facts appear to afford some confirmation of the view presented. Possibly some other combinations of months (*e.g.* May to October and November to April, etc.) might give still better results.

There is another method of dealing with the data, which I would ask you briefly to consider. Taking Dr. Buchan's table of monthly mean temperatures for London,[1] let us first confine our attention to the six months April to September in each *maximum* sunspot year since the beginning of the century, and a year after each; this gives 96 monthly values. Arrange these values in one-degree grades (40° to 41°, 41° to 42°, etc.), then count the number in each grade. Smooth the series of numbers thus obtained with additions of five, and make a curve of the result, taking the degree grades as abscissæ and the month numbers as ordinates. Next do the same with the minimum sunspot years, and a year after each, and put the result in another curve. These curves are shown in the diagram (*h*), the continuous curve being that of the maximum group and the dotted curve that of the minimum. It will be seen that this minimum curve culminates to the right of the other, and its general course is more to the right, indicating a higher proportion of the higher values. Thus the values over 59° are 40 in the maximum group and 51 in the minimum (about 25 per cent more).

This result seems to me an interesting corroboration of the view that has been presented, and it is noteworthy that other European stations yield a similar result. I have applied the method in the case of the north-east of Scotland (*i*), Paris (*j*), and Bremen (*k*). In the case of Bremen, two years after each minimum and maximum have been taken instead of one year. In all four cases the dotted curve is in general to the right of the other.[2]

I regret having been prevented dealing with the winter half in this way to the same extent. At the bottom, however (*l*), will be found curves for Greenwich, the values in the first and fourth quarter being taken in each maximum and minimum sunspot year, and two years after each (since 1841). Here we find the dotted curve, as we should expect, somewhat to the left of the other. Probably treatment of the frost data in this way would give still better results in the winter half.

Conclusion.—The result, then, of these inquiries is, briefly, that in the climate of Western Europe there is apparently a tendency to greater heat in the summer half, and to greater cold in the winter half near the phases of minimum sunspots than near the phases of maximum; the contrast between the cold and heat of the year thus tending to be intensified about the time of minimum sunspots.

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[1] *Journal of the Scottish Meteorological Society*, vol. ix. p. 213.

[2] A curious secondary wave appears in each of these minimum curves. How is it to be explained?

I will not here attempt to discuss at any length the causes of this state of things, but will merely remark that if we accept the view to which direct observation of the sun seems to lead, that solar radiation of heat is greater about the time of maximum sunspots, we appear to have a direct explanation why, on the one hand, our winter cold should thus be moderated; and as to the contrary effect in the summer half, it is not difficult to conceive that increased solar activity may, by increased evaporation, bring about the presence of more cloud, and so give us cool, rather than hot, summers.

DISCUSSION.

Mr. W. **Ellis** said that, not having had time to examine the whole paper, he should confine himself to some general remarks, mainly on the first diagram of the paper, or rather on the two upper curves thereof—the sunspot curve, and that of smoothed mean temperature. He regretted that the figures on which the curves are founded were not given; for, instructive as curves undoubtedly are, if it be a question of giving only figures or curves, and not both, it seems better to give the figures, which more readily admit of combination or discussion. It is remarked in the paper that in many previous researches the year has been considered as a whole, and that a more promising method would be to treat the year in parts, six-monthly or three-monthly periods, or even each month separately. A very proper suggestion, but it should be completely carried out, instead of which the author selects the month of June only for complete discussion. We further read that correspondences previously noticed in one region are not noticed in another, or the correspondence in one region appears even to be opposite to that in another. But yet, in the June curve, the results at places so widely separated as Bremen, Paris, and Geneva are combined. Here the desirability of having the figures for these separate places is apparent, in order to see how far they do or do not support each other. Besides, there is an incompleteness in dealing with a single month. Suppose that May or July, in addition to June, had been employed. Would the same character of curve have resulted? Most probably not, because of the very considerable irregularities of temperature in these three months in different years, which not unfrequently amount to very much more than the whole difference of temperature (about 3° Fahrenheit) sought to be established as depending on sunspots. We further read in the paper that there are six irregular waves of temperature corresponding more or less closely with the six waves of the sunspot cycle, the maxima of temperature coming, on the whole, near minima of sunspots, and the minima of temperature near maxima of sunspots. But examining the two curves, we find that the nearest sunspot minimum to the temperature maximum of 1835 is 1833, two years earlier. Now there is a sunspot maximum in 1837, two years later. Why can 1835 be said to have any more relation with 1833 than with 1837? Again, the nearest sunspot minimum to the temperature maximum of 1859 is 1856, three years earlier; but there is a sunspot maximum in 1860, only one year later. There is discordance also in the case of the maximum temperature of 1887. Similarly, of the five points of minimum temperature supposed to fall with sunspot maxima, two, those of 1843 and 1852, are discordant, especially that of 1843, the nearest sunspot maximum being that of 1848, whilst there is really a sunspot minimum in the year of minimum temperature, 1843. Thus in five out of eleven instances of maximum or minimum temperature, the points of temperature do not fall with sunspot epochs according to the author's view. The treatment is altogether partial. It might have been interesting to have seen what a discussion of the May and July temperatures would have yielded,—better, indeed, each month of the year, because if there be anything in the contention that with minimum sunspots there is a tendency to greater heat in summer and greater cold in winter, the effect should be, it would be expected, a neutral one in spring and autumn. As contrasting with the different character of the relation between sunspots and magnetism, he (Mr. Ellis) exhibited a lantern slide showing the closeness of the relation existing between the variations of sunspots and those of magnetic diurnal range, both as regards coincidence of epoch and accordance in the increased or diminished activity at the different epochs.

Mr. G. J Symons concurred with all Mr. Ellis had said concerning the general points of the paper, and he thought that Mr. MacDowall in drawing his curves had smoothed rather too freely, and that an explanation should be given of the process of adding 5 to the various groups, which he (Mr. Symons) did not fully understand.

Mr. C. Harding said that Prof. Hazen, the American meteorologist, had, he believed, worked on the same lines as Mr. MacDowall, and similarly both Dr. Köppen and Dr. Hahn, except that the latter had discussed seasons instead of months. Both Dr. Köppen and Dr. Hahn in their investigations had embraced the same area as Mr. MacDowall, but strange to say had arrived at diametrically opposite conclusions. In his opinion the results shown by the present paper seemed the more feasible. He believed it was generally accepted that there was a marked connection between rainfall and the appearance of sunspots.

Mr. W. B. Tripp thought that the temperature curve given by the author agreed somewhat with what he remembered in examining the rainfall of the Cape of Good Hope; for whereas in 1878 the maximum rainfall agreed with a minimum of sunspots, in the earlier years the maxima of both rainfall and sunspots more nearly coincided. He thought a calendar month a very unsatisfactory period to deal with in discussions of this nature. If there was a possibility of any lunar influence, perhaps a better time would be a lunar month.

Mr. R. Inwards remarked that probably the only solar spots that had any effect on our weather would be those on or near the sun's equator, so that possibly often when there was a maximum of spots, their position on the sun might be such that they were exercising but little influence on the earth's temperature.

Mr. A. B. MacDowall, in a note to the Secretary, said: "With regard to the June temperature curve, it may be conceded that the correspondence is not complete; and the point to be considered is, whether there is so much correspondence that a connection with the sunspot cycle becomes probable. The possibility of a "lagging effect," in some cases, should, I think, be taken into account. The interpretation of such curves may be, it seems to me, unduly rigid. Thus, *e.g.*, in the case of the third and sixth of those June waves, we should not limit our attention to the culminating points, 1859 and 1887; but should consider the general trend of the curve near those points, and also compare the unsmoothed curve, which presents very high values in 1858 and 1889. Separate smoothed curves of June temperature at four European stations (Paris, Aix-la-Chapelle, Bremen, and Trieste) may be seen in the *Meteorologische Zeitschrift* for November 1896. These curves appear to me to usefully supplement each other; if the correspondence is at one point defective at a given station, it is better at another station.

"Smoothing with *additions* of five, I may explain, is merely one step short of smoothing with *averages* of five. In a series of values, *a*, *b*, *c*, *d*, *e*, *f*, etc., you put the sum of *a* to *e* in the place of *c*, then the sum of *b* to *f* in the place of *d*, etc."

THE USE OF KITES TO OBTAIN METEOROLOGICAL RECORDS IN THE UPPER AIR AT BLUE HILL OBSERVATORY, U.S.A.

By A. LAWRENCE ROTCH, B.Sc., M.A., F.R.Met.Soc.

[Read April 21, 1897.]

It is believed that kites were first used to elevate meteorological instruments, recording their indications graphically and continuously, at the Blue Hill Observatory in August 1894. This permitted simultaneous observations to be obtained in the upper air with kites and near the ground.

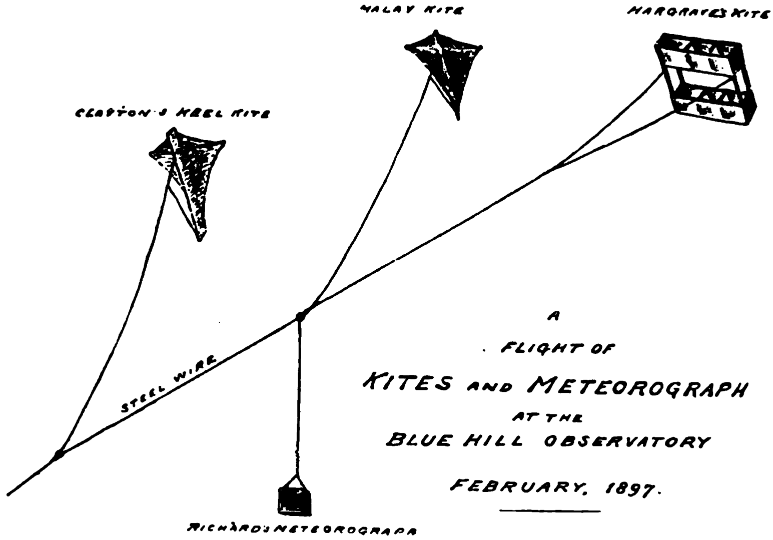
The meteorographs recently employed are an anemo-thermograph, made by Mr. Fergusson of the Observatory, and a baro-thermo-hygrograph made by M. Richard of Paris, which is described and illustrated in *La Nature*, 8 Février, 1896. These instruments are constructed chiefly of aluminium, and each weighs less than 3 lbs. One of them is hung to the end of a steel music wire, having a tensile strength of 280 lbs., between two or more kites which are attached to the wire by independent cords. According to the strength of the wind, other kites can be attached at intervals by a peculiar form of clamp and serve to lift the wire.

The kites are of several types, such as the Malay kite, which presents a convex surface to the wind; the Hargrave cellular kite; and latterly a flat kite with a fin or keel on its front, devised by Mr. Clayton of the Observatory, has been tried.

A hand-winch, provided with a device for measuring the wire uncoiled, is turned by two men to reel in the wire. A steam-winch of two horse-power, with arrangements for automatically distributing the wire on the drum and for recording its pull, has just been constructed by Mr. Fergusson.

The meteorographs have been elevated more than one hundred times, and valuable meteorological data as to the changes of temperature, humidity, and wind up to an extreme altitude of 8,740 feet above Blue Hill have been obtained. The height of a mile has been exceeded on several occasions, and with the new apparatus, constructed by the aid of a grant from the Hodgkins Fund of the Smithsonian Institution, it is expected that records will be brought down from a height of three miles. The altitude may be determined by triangulation from two stations at the ends of a base-line, but more easily by one angular measurement at the winch, the length of kite line being known. When the Richard meteorograph is hidden by clouds, differential measures of altitude are obtained from its barometric records. Measurements of the height and thickness of the lower clouds are frequently made by this method.

Kites are greatly superior to captive balloons for meteorological observations, except during calms or very light winds, which, however, seldom extend aloft. Not only do kites cost very much less than captive balloons, but they can lift a light load, such as a meteorograph, much higher in ordinary winds. The Blue Hill kites fly in all weathers, whenever the wind blows between twelve and fifty miles an hour, whereas captive balloons are driven down by strong winds along an arc whose radius is the lifted cable, and thus transmit violent shocks to the suspended instruments.



A description of the apparatus used at Blue Hill, with a discussion of the results obtained up to the present time under my direction, will be published as an Appendix to the *Blue Hill Observations* for 1896.

DISCUSSION.

Mr. R. H. SCOTT remarked that the first statement in Mr. Rotch's paper seemed to him to require amendment. So far as he knew, the first successful use of kites for raising self-recording meteorological instruments was made by Mr. E. D. Archibald, at Tunbridge Wells (*Quarterly Journal Royal Met. Society*, vol. ix. (1883) p. 62; and *Nature*, vol. xxxi. p. 66, vol. xxxiii. p. 593). The instrument then raised was a Biram's anemometer, and of these four were suspended at different levels. At that date Richard's apparatus had not been constructed of such light materials as to be suited for kite work. The use of wire for the cord was originally suggested by Lord Kelvin. At the International Meteorological Congress of Rome in 1879, Prof. Mendeleef suggested the use of unmanned balloons to carry up self-recording apparatus, but this idea was not then carried out.

Mr. A. L. ROTCH, in reply to a letter from the Secretary, wrote stating that he had credited Mr. Archibald with the first systematic use of kites for meteorological observations (*Proc. Amer. Acad. of Arts and Sciences*, vol. xxxii. No. 13). He had called attention to the fact that Messrs. Alexander Wilson and Thomas Melville in Scotland probably first raised thermometers by means of kites in 1749 (Symons's *Met. Mag.*, August 1896), while Mr. Symons has ascertained that during the winter of 1822-3 the Rev. George Fisher and Captain Sir Edward Parry, with self-registering thermomters attached to kites, obtained temperatures in the Arctic regions (*Met. Mag.*, April 1897). Mr. Archibald, in 1883, with tandem kites elevated anemometers registering on dials the total wind movement from the time the instruments left the ground until their return.

An instrument which recorded its indications graphically and continuously was necessary to obtain the conditions prevailing simultaneously at any level in the free air and near the ground, and without it a thorough exploration of the upper air is impossible. Such an instrument, a thermograph of Richard's pattern, constructed of aluminium by Mr. Fergusson of the Blue Hill Observatory, was for the first time raised by kites from Blue Hill in 1894, and during the following year meteorographs, recording several elements, were there lifted by the same method.

Mr. Archibald appears to have been the first person to fly kites with steel wire, although copper wire was so used by Robert Stevenson when a boy, and copper wire was again used for this purpose in Philadelphia in 1835-6 (*U.S. Weather Review*, November 1896, p. 417). Iron wire for flying "electric kites" was employed in England more than twenty years ago (*English Mechanic*, September 8, 1876, p. 677).

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 17, 1897.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

RUDOLF BLITZ, 74 Leadenhall Street, E.C. ;
WILLIAM VAUX GRAHAM, M.Inst.C.E., 2 Queen Anne's Gate, S.W. ;
ARTHUR LLOYD, Shirley Hurst, Shirley, Croydon ;
ALFRED MALCOLM, 499 Ashton New Road, Clayton, Manchester ; and
S. SIEVERTS-DREWETT, 14 Rue de Chartres, Porte Maillot, Neuilly sur Seine,
were balloted for and duly elected Fellows of the Society.

Mr. G. J. SYMONS, F.R.S., gave a Lecture on "Meteorological Instruments in 1837 and in 1897," which was illustrated by numerous lantern slides (p. 205).

Mr. BIRT ACRES, F.R.Met.Soc., gave a Demonstration with his Cinematoscope of Studies of Form and Movement of Clouds and Waves.

A vote of thanks was passed to Mr. Symons, Mr. Acres, and all who had sent instruments, etc., for the Exhibition.

The Fellows and their friends then proceeded to the Library of the Institution of Civil Engineers and inspected the Exhibition of Meteorological Instruments in use in 1837 and 1897, which had been arranged in commemoration of the Diamond Jubilee of Her Majesty the Queen (p. 221).

April 21, 1897.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

CHARLES HENRY BENN, Free Public Library, Penzance ;
HARRY GEEN, Brandize Hall, Okehampton ;

Thomas Joshua Pemberton, 41a Abbey Road, St. John's Road, N.W.;
Miss Annie Scrivens, Millfield, Bexhill;
Alfred Tate, F.R.H.S., Downside, Leatherhead; and
Henry James Weaver, Guildhall, Gloucester,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

"The Relation between Cold Periods and High Barometric Conditions of Weather in England during the Winter." By W. H. Dines, B.A., F.R.Met.Soc. (p. 237).

"Suggestions of Sunspot Influence on the Weather of Western Europe." By A. B. MacDowall, M.A., F.R.Met.Soc. (p. 243).

"The Use of Kites to obtain Meteorological records in the Upper Air at Blue Hill Observatory, Mass., U.S.A." By A. Lawrence Rotch, B.Sc., F.R.Met.Soc. (p. 251).

CORRESPONDENCE AND NOTES.

Aurora Australis in the South Indian Ocean, April 20, 1897.—Capt. M. W. C. Hepworth, F.R.Met.Soc., has forwarded the following notes on the Aurora Australis observed on board the Canadian-Australian R.M.S. *Aorangi.*

On April 20, 1897, in latitude 47° 30′ S., longitude 96° 15′ E., at 6.30 p.m., a diffused light, bearing resemblance to that which may be observed at night over a city strongly lighted by electricity, was observed over the southern arc of the horizon. Horizontal flashes soon spread and flared in every direction from this light above the horizon, increasing in length and brilliancy, until at 7.30 p.m. they were shooting across the sky to within 30° of the northern arc of the horizon. Cones and circles of light travelled rapidly over the whole sky, flashing beams of intense brilliancy from one to the other. This continued until 8.30 p.m. A remarkable change then took place: the sky being cloudless, moon and stars shining brightly, an arch of bright green light fading off into yellow, formed over the southern horizon, rose rapidly to a higher and yet a higher altitude, and was followed by similar arches in regular sequence, until there were six distinct arches, their apices being from 10° above the southern horizon to 60° above the northern horizon. They were formed of narrow vertical bands of light from 5° to 20° deep, bright green and yellow at their upper edges, and of a rosy hue at their bases. Subsequently these arches rapidly changed their shapes in all parts of the sky, others forming, but some kind of sinuous curve was always preserved, excepting in one or two cases, when perfect right angles were formed. At 9 p.m. a brilliant circle formed round the zenith, composed of narrow bands of light, similar to those already described, but pendant overhead and having a rotary motion. This circular motion was apparent in all the formations previously mentioned. The circle was about 30° in diameter, and the rays of coloured light or narrow bands of coloured light, as I have elsewhere termed them, were not quite vertical, but slightly inclined, thus producing an effect which gave the impression of what one might suppose would occur in the vortex of an electrical cyclone. A cloudless sky showed through the centre of this ring-shaped tassel of coloured light, which travelled to the westward. Later, a spiral cord of light formed, having its centre at the zenith, exhibiting three distinct turns of a coil. Two intensely bright formations, resembling waterspouts brilliantly illuminated, flared in the west, and a remarkably bright meteor, starting from *Canis Major*, travelled slowly across the sky, discharging at intervals fragments of colour, and thus adding to the splendour of the scene. Prior to 8.30 p.m. all the flashes of light had been horizontal, after that time they were all vertical. A special feature in this display should be mentioned; these formations had all a westward movement. After 9.15 p.m. the aurora was less brilliant, but burst into greater activity a few minutes afterwards, more especially in the northern semicircle. This display lasted until 9.45.

Atmospheric pressure for the past 48 hours had been abnormally low, the barometer remaining below 29 inches. At the time of the display it stood at 28·80 ins. and was slowly rising. The temperature of the air was 43°, the wet-bulb reading being 41°. The wind was from West-north-west (true), force from 5 to 4; it had been North-west throughout the day, force 7; and on the day previous North-west, force from 6 to 8. Squally weather accompanied by rain, hail, thunder and lightning, had been experienced from the 18th until noon of the 20th.

On the night of April 22-23, in latitude 45° S., longitude 118° to to 120° E., from 7 p.m. to 4 a.m., another auroral display was observed exhibiting the phenomena of the arches. At 9 p.m. two arches, one after the other, rose slowly above the horizon, but on this occasion the sky became frequently clouded, and the spectacle, although magnificent, had not that awe-inspiring grandeur which startled the eyes of the observer on the night of the 20th.

Tornados in the United States, 1889-1896.—On the night of May 27, 1896, a very violent tornado swept across the city of St. Louis, Mo., and caused the death of 360 persons, as well as wrought immense destruction of property. This disaster has been the means of awakening general interest in tornadic phenomena, and also of stimulating the business of tornado insurance throughout the great interior valleys. With the view of supplying reliable information on the subject, the chief of the Weather Bureau instructed Mr. A. J. Henry to discuss the reports of tornados, etc., which had been received by the Weather Bureau during the period 1889-97. Mr. Henry's report has been published in *Report of the Chief of the Weather Bureau*, of which the following is a summary.

The chief characteristics of a tornado are assumed to be (1) a pendant funnel cloud; and (2) violent, rotary winds over a well-marked but narrow path. All storms not fulfilling these conditions were rejected. When it was impossible to see the cloud mass on account of darkness, the evidences of whirling found in the *debris* were accepted as indicating the character of the storm. It was possible to determine the nature of the majority of storms reported. In a few cases the evidence was not conclusive, and the storms were rejected. Such cases, however, form but a small percentage of the whole.

From the nature of the case there is considerable uncertainty as regards the path of great destruction, particularly the length. It is obvious that the length of the path of great destruction cannot be accurately determined except by personal inspection. Tornados have been traced in an uninterrupted course for a hundred miles. Such cases, however, are exceptional. During the eight years under consideration, tornados of unusual length and violence occurred on June 15, 1892; April 19 and July 6, 1893; September 21, 1894; and May 17, 1896. The width of the path of great destruction is more accurately stated, although it is apparent that at times the reporter gave the width of the whole path over which destruction was observed. The tornado of April 19, 1893, is a notable example of a storm in which the path of great destruction was unusually wide. Reliable information from independent sources establishes the verity of the statement which appears in a report from Pachuta, Miss., dated May 2, 1893: "The width of the path of great destruction in the storm was from 1 to 2 miles; everything was swept away; even the growing grass seemed as though a tide of water had passed over it. About the centre nothing was left."

The direction of movement in the great majority of cases is toward the north-east, and there is a decided tendency at times to form and move in that direction in parallel lines.

The character of the tornado cloud seems to vary somewhat with location, and probably with the hygrometric state of the air. In the Dakotas, Nebraska, Kansas, and Oklahoma, the funnel cloud is frequently observed for miles as it passes over the prairie. It is generally clear cut, well defined, and when quite narrow exhibits the characteristics of an over-grown whirlwind. In the Gulf States and the humid regions of the Atlantic seaboard the funnel cloud is not so well defined, and cases of severe tornados are on record wherein the funnel cloud was absent.

As the work progressed it became evident that a rigid adherence to the rule adopted for classifying tornados would include a number of storms which, by the accident of chance, passed through a thinly settled region or diminished in intensity before reaching any considerable settlement. The property loss caused by a single severe hailstorm is often greater in the aggregate than that of a dozen such storms, yet their insertion in the lists is proper and necessary.

It appears that certain portions of the United States are exempt from tornados, while other portions, notably the great interior valleys, are subject to them each year. It is also noticed that while the number of storms varies each year, there is little change in the locations in which they occur. The relative frequency in the several months of the various years is also fairly constant. It is found that in the winter months tornados occur in the Gulf States only; that with the gradual warming up of the valleys and plains of the interior they occur farther and farther to the northward until the month of June, which is the month of greatest frequency in Nebraska, South Dakota, Iowa, and Minnesota. The northern half of North Dakota, a portion of northern Minnesota and Wisconsin, are practically free from tornados, but the country southward to the Gulf and eastward to the Atlantic is more or less liable to be visited by them. Some portions of this vast expanse of territory have never been visited by a tornado, and possibly never will be.

During the period of greatest frequency in northern latitudes very few tornados occur in the Gulf States, and many more occur in May and June in the middle and northern latitudes than at any other place, or during any other period of the year. During the eight years there have been 6 days in January on which tornados occurred, 10 in February, 16 in March, 31 in April, 42 in May, 51 in June, 25 in July, 11 in August, 4 in September, 2 in October, 3 in November, and 5 in December. It must not be assumed that the same relative frequency obtains each year. Occasionally there are more tornados in April than in any other month, yet on the average of a number of years it is probable that there will be more in May and June than in any other corresponding period.

The storms of April and May frequently occur almost simultaneously over very considerable areas, while the storms of the summer and winter months are, as a rule, restricted to the smaller limits of a single State. The widespread storms of April 11 and 12, 1893, serve to illustrate this distinguishing feature of April and May storms.

The very destructive storms occur principally in the late spring and early summer months (March to June inclusive). During the eight years no severe tornado has occurred in August west of the Allegheny Mountains, and but one each in July, September, and October. In the middle States and New England on the other hand, no very severe tornado has occurred before July or August, generally the latter month.

The following figures show the estimated property loss in dollars by tornados during each year of the period 1889-96:—

1889	1890	1891	1892	1893	1894	1895	1896[1]
$173,500	4,449,800	186,600	1,118,000	2,043,800	1,192,900	383,700	14,218,900

The estimates on which these figures are based were made, in the majority of cases, by persons on the ground at the time of destruction. In some cases they were made by Mr. A. J. Henry, based on a report of the number and character of buildings destroyed. How near the estimated amounts approach actual losses is of course impossible to determine. It is believed that they are close to the truth in the majority of cases; there are some instances, however, in which the estimates seem to be rather high. The number of storms and the property loss bear no definite relation to each other, and the latter is very irregularly distributed throughout the eight-year period. More than half of it—over $12,000,000—is chargeable to less than a half-hour's destruction in St. Louis, Mo., and East St. Louis, Ill., on May 27, 1896. The year having the next greatest loss (1890) was also marked by very great destruction in Louisville, Ky. It was estimated that property aggregating in value over $2,000,000 was destroyed in that city alone, more than the total destruction of any other year except 1896. Happily, instances of such great destruction are quite rare.

More than 90 per cent of the property loss of the eight years fell on 24 days. The remaining 10 per cent was distributed throughout 183 days, in which tornados of greater or less violence occurred. This fact should not be overlooked. The great tornados of the eight years have averaged about 3 per annum. There were none in 1889, 4 in 1890, none in 1891, 4 in 1892, 7 in 1893, 3 in 1894, none in 1895, and 6 in 1896. Lists of very destructive storms for the 18 years previous to 1889 show an average of 3 per annum; we are, therefore, reasonably certain that the average of really destructive storms (say those in which the loss is $100,000 or more) is not above that number.

Atmosphere in relation to Human Life and Health.—Some time ago the Hon. F. A. Rollo Russell submitted a memoir on this subject in the Hodgkins Fund Prize Competition of the Smithsonian Institution, for which he was awarded honourable mention with a silver medal. This memoir has now been published by the Smithsonian Institution in a separate form, and extends to 148 pages octavo.

The work is divided into four parts, viz.—I. Constitution and Conditions of the Air; II. Climate, Air, and Health; III. Various Atmospheric Conditions and Phenomena; and IV. Subjects for Research.

Mr. Russell concludes the memoir with a section "On some possible modifications of climate by human agency." After referring to the distribution of rainfall over the British Isles, and the effect of elevation in increasing the rainfall, the author says: "Now, the practical inference from these statistics is that it may be possible where desirable to imitate natural barriers on a small scale, and to increase rainfall in their proximity in order to diminish it elsewhere. Thus, if between Chichester and Arundel the natural height of the Downs were to be raised by 300 feet, the rainfall would be increased a mile or so southward and perhaps a few miles northward, but would be diminished over the northern half of Sussex, and probably in Surrey, to an appreciable degree. . . . The effect of a wall, like that of a perpendicular cliff, would be to drive the impinging air vertically upward, so that the increased rainfall would take place near the wall and a little to leeward."

Climate of Geneva.—Mons. R. Gautier has communicated to the *Archives des Sciences physiques et naturelles* a paper giving the means of the principal meteorological elements at Geneva for the 70 years 1826-95. This is in continuation of the summaries made by Plantamour and Kammermann.

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[1] To June 30 only.

The following are some of the chief mean monthly results:—

	Temperature.			Rainfall.	
	Mean.	Mean Max.	Mean Min.	Amount.	No. of Days.
	°	°	°	in.	
January . .	31·5	37·2	26·3	1·77	10·0
February . .	35·0	42·0	28·7	1·60	8·9
March . .	40·4	48·7	33·2	1·88	10·4
April . . .	48·2	57·4	39·8	2·36	11·6
May . . .	55·6	64·4	46·4	3·23	12·7
June . . .	62·2	72·5	52·5	2·98	11·5
July . . .	65·9	76·5	55·7	2·91	10·4
August . .	64·4	75·1	54·7	3·29	10·5
September . .	58·4	68·0	51·8	3·63	10·6
October . .	49·5	57·9	42·8	4·13	12·1
November . .	40·5	46·6	35·3	3·10	11·8
December . .	33·5	38·6	28·7	2·07	9·9
Year .	48·8	57·1	41·3	32·95	130·4

RECENT PUBLICATIONS.

Annuaire de la Société Météorologique de France. Avril—Juin 1896. 4to.

Contains:—Les vents supérieurs: par M. Hauvel (8 pp.).—Sur les hautes pressions atmosphériques du mois de janvier 1896: par Père M. Dechevrens (3 pp.).—La chambre noire néphoscopique: par L. Besson (3 pp.).—Sur un nuage particulier au vent de Nord-Ouest: par P. Cœurdevache (1 p.).—Décroissance de la température dans la verticale suivant le gradient barométrique: par P. Cœurdevache (1 p.).—Sur le climat de Châteaudun: par E. Roger (7 pp.). This gives a summary of the meteorological results for the 30 years 1866-95.

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. April—May 1897. 4to.

The principal articles are:—Die Ergebnisse der ersten internationalen Ballonfahrt in der Nacht vom 13 zum 14 November 1896: von H. Hergesell (21 pp.).—Die zweite internationale Ballonfahrt am 18 Februar 1897 (3 pp.). These two papers, of which the second is only a preliminary notice, give accounts of the two first flights of balloons organised by the Balloon Committee of the Paris International Meteorological Conference, of which Dr. Hergesell was the chairman. Balloons were sent up on the first occasion from Paris, Strassburg, Munich, Berlin, Warsaw, and St. Petersburg; most of these were unmanned, but manned balloons ascended also from Munich, Berlin, Warsaw, and St. Petersburg. The results of each ascent are separately discussed, and some very interesting observations were recorded. Among others was the fact that at a very considerable elevation (over 16,000 feet) a comparatively warm temperature stratum was encountered, but this was registered especially by the Strassburg and Berlin unmanned balloons, so that beyond the fact of its existence not much can be considered as established (see *Quarterly Journal*, vol. xxiii. p. 201). The experience of the first ascent was very valuable, and on the second occasion the observations were more completely organised.—Ueber die Häufigkeit der Frost-, Eis- und Sommertage in Nord-Deutschland: von Dr. G. Schwalbe (10 pp.). Ever since 1879 the publications of the Prussian Meteorological Institute have given in a tabular form for each month the number of days with (1) minimum below 32°; (2) maximum below 32°; and (3) maximum above 77°. The last named are termed "summer days." Dr. Schwalbe points out that the results are seriously affected by the irregularity of exposure, as several stations still have the window exposure, at a considerable height above the ground. He finds about the "frost days"—(1) The number is independent of latitude; (2) it increases with distance from the sea and from the western frontier of Germany; (3) it increases with altitude above sea-level; and (4) it depends on soil, and is very high in boggy ground. As to the "ice days" (maximum below 32°) the number increases (1) in the direction from south-west to north-east; and (2) with altitude above sea-level. Local conditions hardly affect it. As to the "summer days" the number decreases—(1) With nearness to the coast; (2) in the direction from south to north, but not very markedly; (3) there are more of these days in the east than in the west; and (4) the number decreases rapidly with elevation above sea-level. Dr. Schwalbe points out "hot days" would be a better description of these days than "summer days."—Bemerkungen über die Temperatur russischer Flüsse und Seen: von. A. Woeikof (4 pp.). This is in the first place a notice of two years' observations of the temperature of the Dneiper at Kiew, and there the water is always warmer than the air. Dr. Woeikof also discusses other observations on the water of rivers and lakes, and concludes with a criticism of a statement of Andrejew's that the temperature of Lake Ladoga is from 2° to 3° R. from the disappearance of ice up to midsummer, but is higher in August, but not above 5° or 6° R. Dr. Woeikof proceeds to show that the water must be much warmer than the figures given above, and he gives a comparison between the summer temperatures at Walaam on Lake Ladoga, and at Kultuk on Lake Baikal in support of his argument.

Proceedings of the American Academy of Arts and Sciences. Vol. XXXII. No. 13. May 1897. 8vo.

Contains:—On obtaining meteorological records in the upper air by means of kites and balloons: by A. L. Rotch (7 pp.). The author gives an account of various methods that have been employed with kites and unmanned balloons for obtaining continuous records of the chief meteorological conditions of the upper air. An account of the experiments with kites at the Blue Hill Observatory, Mass., is given on p. 251.

Report of the International Meteorological Congress held at Chicago, Ill., August 21-24, 1893, *under the Auspices of the Congress Auxiliary of the World's Columbian Exposition.* Edited by O. L. Fassig, Secretary. Part III. 8vo. 1896. 188 pp.

Part III. contains the papers read in Sections VII. and VIII. Section VII., which is devoted to Climatology, contains twelve papers on the climate, etc., of the following countries, written mostly by the heads of the various meteorological services: The United States; The West Indies; City of Mexico; The British Isles; The Netherlands; Denmark; Norway; The German Empire; Austria-Hungary; The Italian Mountains; The Malay Archipelago; and Southern and Western Asia.

Section VIII., which is devoted to Instruments and Methods of Investigation, contains the following papers:—Historical sketch of instrumental meteorology: by Prof. E. Gerland.—The relative merits of anemometers in general use: by W. H. Dines.—Relative merits of the various types of registering maximum and minimum thermometers: by Dr. D. Draper.—On the construction of registering air thermometers to replace the ordinary alcohol and mercurial thermometers: by Dr. A. Sprung.—Observations of solar radiation—how best made and compiled: by Prof. O. Schwolson.—The study of the upper atmosphere by means of balloons: by Dr. V. Kremser.—**Observations of** atmospheric dust: by J. Aitken.—The study of the upper atmosphere from observations on mountain stations: by Dr. J. Hann.—The study of the upper atmosphere by means of cloud observations: by Dr. Vettin.—Cloud photography: by A. Angot.

Symons's Monthly Meteorological Magazine. April—June 1897. 8vo.

The principal articles are:—The first Daily Weather Map (1 p.).—Scientific Kite work in the Arctic Regions (1 p.).—Diamond Jubilee Meeting and Exhibition of the Royal Meteorological Society (4 pp.).—Hailstorm in South London (2 pp.). This storm, which was very severe in Tooting, Streatham, and Brixton, occurred on April 27. A full account of the storm will be found in a paper by Mr. C. Harding, which will be printed in a subsequent number of the *Quarterly Journal.*—The formation of Dew: by Dr. J. G. M'Pherson (2 pp.).—Hailstorm at Seaford, Sussex, May 30, 1897 (8 pp.). Thunderstorms of more or less intensity prevailed on this day over the greater part of the east of England, but the most severe was that which occurred over an area less than 4 miles from east to west, about midway between Newhaven and Beechy Head, and 8 miles from south to north. In this storm hailstones of very large size fell, many being 2 inches in diameter and 7 inches in circumference.

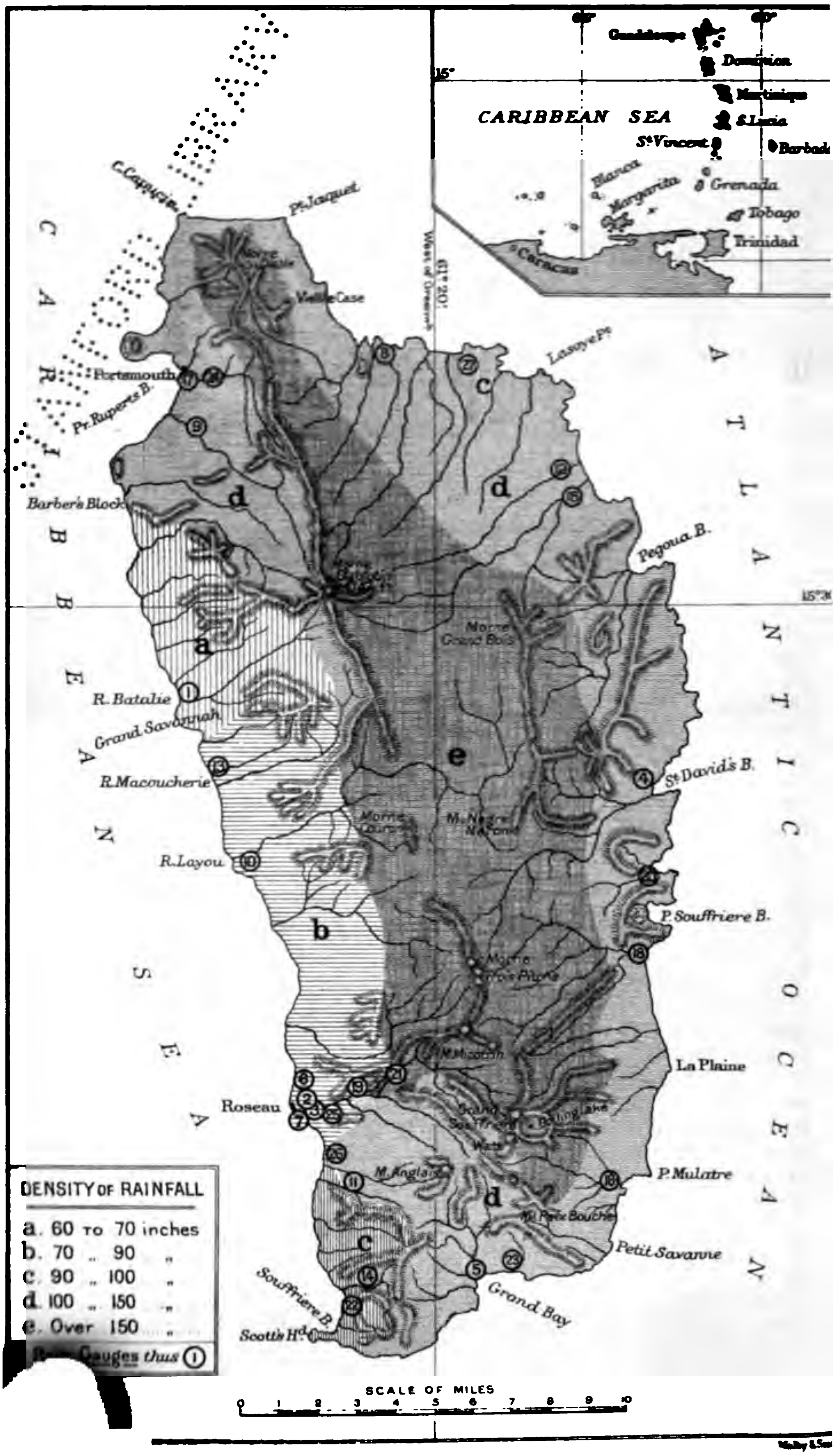
The Story of the Weather, simply told for General Readers. By GEORGE F. CHAMBERS, F.R.A.S. Sm. 8vo. 232 pp. 1897.

This little book is one of a series of popular books published by George Newnes, Limited. The author states that this work "does not in the least pretend to being a formal treatise on Meteorology regarded as an exact Science, but is merely designed to present in a handy form, and in an unconventional style of language, a certain number of elementary facts, ideas, and suggestions which ordinary people, laying no claims to scientific attainments generally, are usually glad to know."

Waters within the Earth and Laws of Rainflow. By W. S. AUCHINCLOSS, C.E. 43 pp. 8vo. 1897.

The object of the author has been to supply the missing history, and to develop the laws of subterranean flow, or, as he terms it, "rainflow." It is shown that a very large part of the annual rainfall passes away *over* the surface of the ground. Hence the importance of using every means to preserve our forests. For wherever the country is thickly wooded, the undergrowth, ferns, leaves, and mosses arrest the flow of water, to the great benefit of the land; freshets seldom occur, while protracted periods of drought, and failure of springs are scarcely known. The author points out that the withdrawal of a thousand gallons from any well, located in a compact soil, disturbs the ground water level over many acres of ground. It is therefore prudent always to anticipate the encroachments of a growing population by providing an independent water-supply, located far beyond the reach of contaminating influences. This investigation shows the relation between rock- and water-sections; also the analogy existing between the laws of subterranean flow and the laws governing the discharge of water through a weir; the nature and process of recovery, likewise the relation between uniform flow and fading flow. Attention is also directed to the fact that the mean daily temperature of ground water is the same as the yearly average temperature of the air.

ANNUAL RAINFALL, DOMINICA, WEST INDIES.



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THE RAINFALL OF DOMINICA.

BY C. V. BELLAMY, F.R.Met.Soc., Assoc.M.Inst.C.E., F.G.S.

(Plate V.)

[Read May 19, 1897.]

THE Island of Dominica forms one of the group of Lesser Antilles in the British colony of the Leeward Islands of the West Indies; it is situated between latitude 15° 20′ and 15° 45′ N. and longitude 61° 13′ and 61° 30′ W., and measures about 29 miles in length and 16 miles in breadth, and contains about 291 square miles. The island was discovered by Christopher Columbus on Sunday, November 3, 1493, on his second voyage, and derives its name from the first day of the week, and in consequence is known sometimes as "Sunday Island." The French islands of Guadaloupe and Martinique lie to the north and south of it respectively, being each distant about 30 miles. It is, like most of the islands in this group, volcanic, and is one of the few British West Indian Islands which still display volcanic activity.

The island is throughout very mountainous, and but a short distance from the shore the land rises in many instances to altitudes of over 1000 feet above sea-level. There are many peaks over 3000 feet, the highest of all being Morne Diablotin, 4747 feet; while the other important eminences are Morne Trois Pitons, the highest of the three peaks rising to an altitude of 4672 feet; Watt Mountain, 4075 feet, on the northern slope of which is the Boiling Lake and Grand Soufrière; Morne Micotrin, 3891 feet; Morne Anglais 3748 feet; and in the extreme north Morne-au-Diable, 2917 feet.

There is a remarkable degree of boldness and grandeur in the scenery of the island. Dark irregular masses rise abruptly from the sea, sweeping upward in ever-changing curves and profiles, as if thrust heavenward by some great convulsion of nature. From the seashore to summit the entire surface is clothed in a mantle of green, which, upon nearer inspection, discloses that luxuriance of foliage which characterises the intertropical portions of the western hemisphere, indicating unsurpassed conditions of climate. Deep ravines, fertile vales, frowning cliffs, surmounted by wooded steeps of lofty mountains, alternate with each other, all harmonising in one living picture of glorious nature. The prodigality of the growth is astounding,—not alone the trees and shrubs which surmount each hill or carpet each vale, but even the faces of precipices, are seen to be draped with lianes, vines, and creepers, combining to frame each harshness in a border of exquisite lacework. Ravines and hillsides are decked with tree ferns; while from every tree depends some parasite, orchid, or creeper, adding its lovely blooms to the charm of the scene.

There are numerous rivers; one, it is said, for every day in the year, all flowing perennially with clear, sparkling water, and abounding in fish. The largest river is the Layou, rising on the western slopes of the Pegoua Hills, and traversing a rich tract of magnificent virgin forest known as the Layou Flats, where the fertility of the soil must be beyond all question; tributaries of the Layou traverse other tracts equally fertile, known as the Sara, the Pagailleu, and the Fond Zombi Flats. Other rivers of importance are the Roseau, giving its name to the chief town of the island; the Rosalie, the Castle Bruce, the Pegoua, the Melville Hall, the Londonderry, Clyde, or Toulamon, the Hampstead, the Boery, etc. etc.

The surface of the land is broken up into irregular ranges of hills, particularly in the southern half of the island, as a glance at the rainfall map (Plate V.) will show; but north of the Trois Pitons there are three more or less distinct ranges, the main one going northward through the entire length of the island and terminating in the neighbourhood of Morne-au-Diable. This range, forming, as it were, the backbone of the island, culminates in the Morne Diablotin; while to the eastward lie two ranges, one between Morne Nègre-Maron, 2500 feet, known also as Morne Lorent or Gris-Gris, and Morne Grand Bois forming the Pegoua Hills; the other stretches from Morne Bois Diable as far as Pegoua Point to the south of Pegoua or Commissioner's Bay.

The Trade Wind, blowing in from the Atlantic and bearing with it a vast amount of aqueous vapour, is intercepted by these ranges, so that the tract of country on the windward or eastern slopes of these hills receives the greatest amount of rain, while that on the leeward or western side of the three ranges is the driest district in the island, viz.: the portion represented by the rainfall collected at Batalie. The mean rainfall at this point for the four years 1893-96 amounts to 67·97 ins. The minimum for this period 41·72 ins. for the year 1894, being an exceptionally low figure for a mountainous country within the tropics. On the windward side of the island a vast difference is observable; such, for instance, as at Castle Bruce, where there is a mean rainfall for the same period of 162·04 ins., or at Saint Sauveur 156·80 ins., where during the past year (1896) 210·02 ins. fell; or again at Rosalie, where 202·07 ins. were recorded during the year 1896, the mean for four years being 161·42 ins.

The Atlantic Trades are the prevailing winds, there being but little variation in the direction of the air-currents. Such variation as there may be occurs for the most part at the periods when the sun approaches the zenith. Then occasionally light breezes set in from the Carribean Sea, warm and vapour-laden, raising the temperature of the air somewhat, and having a more relaxing, depressing effect on the leeward coast than the Atlantic breezes have on the windward side of the island. In fact, it may be said that the sea-breeze on the windward coast is bracing and invigorating, while the corresponding breeze upon the leeward side is extremely enervating, but it does not extend over any considerable period. While the Trade Wind brings so much rain to the windward coast, it has the effect, after being deprived of much of its moisture from contact with the numerous high peaks and mountain ranges, of descending upon the leeward coast from a height of from 3000 to 5000 feet, in the form of a cool, comparatively dry breeze, lowering the temperature to a point seldom known at sea-level within the tropics, and rendering the neighbourhood more highly favoured in this respect than most of the islands in the group. It is, in fact, no uncommon thing to find in Roseau the thermometer recording in the early mornings a temperature considerably below 70°, so that the nights are invariably cool and refreshing.

The "Hurricane Season," as it is termed, or that period during which hurricanes may be expected, extends from July to October. The last visitation of that nature occurred in September 1883. Among the principal storms or other phenomena recorded in the history of the island the following events are more or less worthy of note:—

1765. A hurricane and several violent shocks of earthquake were felt in April and May.
1772. Eighteen vessels driven ashore in a heavy gale of wind and lost.
1776. A hurricane.
1780, Sept. 30. A tidal wave, the sea rising 21 feet above normal level, destroying many houses and wrecking many vessels.
1780, Oct. 10. A hurricane.
1787, August. All the buildings on Morne Bruce (formerly the garrison), the shipping, and some houses in Roseau were destroyed by three gales of wind on the 3rd, 23rd, and 29th.
1806, Sept. 9. A dreadful hurricane caused terrible havoc throughout the island, the towns, garrison, and estates sustained the greatest injury; Roseau River overflowed and inundated the Capital; a number of houses were carried away and 131 persons killed.
1813, July 22. Most destructive hurricane; Government House, Court House, etc., razed to the ground.
1817, Oct. 21. A hurricane.
1818. A severe flash of lightning accompanied by an awful clap of thunder
1820, Sept. 26. A severe storm.
1822, Dec. 19. A severe storm.
1823, Nov. 11. A severe shock of earthquake.
1824, Sept. 8. Destructive gale.
1825, July 26. Severe gale, several ships wrecked in Roseau, and an immense tamarind tree in the Market torn up by the roots.
1826, May 5. A smart shock of earthquake.
1827, July 27. A smart shock of earthquake, followed by a severe thunderstorm and heavy rains.
1827, Nov. 30. An earthquake.

1829, Aug. 3. Severe thunderstorm, with lightning and wind.

1834, Sept. 20 and 21. Great hurricane, doing immense damage in every quarter of the island.

1838, June. Several smart shocks of earthquake.

1841, Aug. 17. A smart shock of earthquake. A succession of smart earthquakes was felt in the Prince Rupert's (Portsmouth) District for three weeks.

1843, Feb. 8. A severe earthquake did much damage chiefly at windward, and destroyed the works at the "Melville Hall" and "Londonderry" estates; injuring also the Roman Catholic Church in Roseau and the Wesleyan Chapel at Prince Rupert's (Portsmouth). This was the longest and strongest earthquake yet felt in the island. (N.B. The greater part of the town of St. John's, Antigua, was destroyed at the same time.)

1844, Jan. Smart shocks of earthquake.

1845. Extraordinary heavy floods in the windward quarter, doing immense damage to the sugar plantations and buildings.

1847. In December of this year fell the heaviest rains ever known in the island. The roads were almost obliterated, and the new canal for bringing water into the town was destroyed; nearly every estate in the island suffered severely; Roseau being partially submerged.

1848. Severe shocks of earthquake in the southern part of the island.

1849. A severe shock of earthquake in Roseau.

1857, Feb. Bad weather this month. An overflow of the Roseau River carried away a large portion of land on its left bank.

Hurricanes are reported to have also occurred in 1764, 1815, 1818, 1819, 1826 in addition to those enumerated above, but these do not appear to have been of any great magnitude or to have caused much damage. It appears that such violent storms are of less frequent occurrence now than they were formerly.

In compiling the accompanying rainfall statistics care has been taken to collect only the most reliable data; the task has not been altogether an easy one, as in only a few cases is the subject treated with that importance which it deserves.

A map (Plate V.) has been prepared showing more or less accurately the density of the rainfall throughout the island. This has been compiled from records kept at 27 stations about the island during the years 1893, 1894, 1895, and 1896. That previous records are not given is due to the fact that, though they may exist, they have not been published.

In the matter of comparison the map is fairly correct, but the absence of stations in the interior of the island render accuracy impossible. Again, in certain instances the nature of the surrounding country is such as to preclude the acceptance of the observations as being representative of the district generally. For instance at Saint Sauveur, immediately north of Petit Soufrière Bay on the windward coast, high hills rise abruptly to the west and cause a fall of rain, which cannot in fairness be held to represent the district. Another similar case is at Shawford, situated not more than 3 miles from Roseau. This estate lies in a hollow surrounded by hills rising, particularly on the western and northern sides, abruptly over a thousand feet above the station, with the result that the rainfall there collected far exceeds that of any other station in the island. The mean for the four years under review is 196·19 ins., while the maximum rose to 234·67 ins. in 1895, and in the previous year, 1894—generally considered a dry year—as much as 149·86 ins. was recorded, this being the minimum for the same period. Not more than a mile lower down the Roseau Valley, and to the westward of Shawford, is Saint Aroment, where the mean rainfall for 20 years, 1876 to 1895, was 105·03 ins. A difference so great as this must be due without question to the configuration of the country.

The tract of country in the centre of the island, where also the best and most fertile land is situated, receives a rainfall probably exceeding 200 inches a year; while the driest district is that lying immediately to leeward of the three main ranges of hills, or situated between the River Layou and Barber's Block. The mean rainfall for this neighbourhood is probably under 70 ins., although in the preparation of the map it was deemed advisable to exclude Macoucherie and Hillsborough, as the returns for these stations are not complete.

There are five degrees of density shown on the map; the first, from 60 to 70 inches, including the district just referred to, viz.: Batalie; the second, to the south of this district, extending as far as Roseau, or a little to the south of it, where the annual fall may be set down at from 70 to 90 inches, includes the stations of Bath—taken to represent the district about Roseau—the Botanical Station, Goodwill, Government House, Hillsborough, Macoucherie, and the training school at Morne Bruce, now closed. To the south again of this district is one where the fall is between 90 and 100 inches, and represented by the station of Soufrière. On the north-east coast is shown another small district represented by the station of Woodford Hill; this, however, must be accepted with reserve. The mean for the four preceding years is 107·92 ins., due to an abnormal fall during the last year, 1896; but the mean for ten years, 1885-94, 102·96 ins., affords some reason for its being distinguished from the surrounding neighbourhood, such as Melville Hall, for instance, where the mean for four years is about 19 inches more. The fourth degree of density, from 100 to 150 inches, covers the greater part of the country from Portsmouth (Prince Rupert's) around the windward coast to the south of the island, and includes the stations of Hatton Hall, Portsmouth, Sugar Loaf, Hampstead, Londonderry, Melville Hall, Castle Bruce, St. Sauveur, Rosalie, Point Mulatre, Stowe, and Geneva. Castle Bruce, Rosalie, and St. Sauveur exceed, however, 150 inches, but, as suggested above, it is a question whether such records represent the districts in which they lie. The fifth degree of density has been already described; and it is not too much to say that the fall for this district may be set down at anything over 150 inches. A fertile tract of country, at an altitude seldom less than 1000 feet above sea-level, clothed in magnificent primeval forest containing trees of noble proportions and of great value, where the mean temperature is probably but little above 60°, only awaits capital and enterprise to convert it into a healthy, health-giving Eden of loveliness second to none in producing powers.

In Tables I.-IV. are given the monthly rainfall returns from 17 stations for the year 1893, 23 for 1894, 19 for 1895, and 20 for 1896, out of a total of 27 where from time to time observations have been recorded.

From these returns a selection has been made for the purpose of compiling Table VI., representing the mean rainfall for the whole, viz. Batalie, as representing the minimum rainfall; Bath, as that for the neighbourhood of Roseau; Geneva, for the south; Hampstead, for the north; and Rosalie, as being one of the wettest stations in the island. This is at least the fairest selection that could be made by reason of the surrounding country being more open than at other stations.

From Table VI., which gives the mean monthly rainfall for the four years, it will be seen that the rainy season extends over the months of July, August, September, October, and November; the remaining seven months representing the dry season. The mean monthly rainfall is 9·22 ins.

The minimum rainfall for any one month during the whole period was 0·00 in. at Batalie in April 1894; the maximum fall, 76·85 ins., occurred at Rosalie in November 1896, a fall without precedent in this island, and probably but seldom recorded in any part of the world. The month of November 1896 was indeed one of phenomenal rainfall as well in Dominica as elsewhere. The least rainfall for that month was at Wall House, where 13 inches were recorded. Six other stations recorded from 13 to 20 inches; six others from 20 to 30 inches, and nine others recorded over 30 inches. The falls along the windward coast were:—Castle Bruce, 59·09 ins.; Hampstead, 41·45 ins.; Melville Hall, 53·51 ins.; Point Mulatre, 49·02 ins.; Rosalie, 76·85 ins.; St. Sauveur, 71·57 ins.; and Woodford Hill, 50·85 ins. But for the heavy rainfall in the month of November the year 1896 would have been one of comparative drought.

This incident deserves to be recorded in the annals of the island; for, the floods accompanying this fall caused terrible havoc to many of the estates on the windward coast. At Hatton Garden, through which the Pegoua River discharges into Pegoua or Commissioner's Bay, the entire alluvial flat planted up in sugar canes was swept absolutely clear of all sign of vegetation, and immense quantities of *débris* were borne down by the flood. South of this point is Salybia, the reserve allotted by the Crown to the Caribs, the few remaining aborigines. It is reported that the whole of this quarter is split and rent by chasms and fissures of great depth, and the land for some miles is in danger of being precipitated into the sea, a catastrophe which may occur at any time should an abnormal fall of rain occur. It is to be noted that this tract of country, as well as that in which the Pegoua River rises, lies in the path of the storm clouds which passed over Castle Bruce, where 59·09 ins. were recorded in the month referred to.

That greater damage was not caused in the face of such a rainfall is matter for wonder; but it may be explained in some measure by the tenacity of the soil, the abrupt slopes of the hillsides, or the more or less common occurrence of heavy downpours of rain, as much as 10 inches of rain having been registered in one day at Castle Bruce in the month of December 1895; while in the same month Woodford Hill recorded 31·23 ins., St. Sauveur 30·44 ins., Rosalie 24·25 ins., Melville Hall 30·00 ins., and Castle Bruce itself 36·61 ins. This month was hardly, however, to be compared with November 1896. Again, in September 1895 twelve stations out of nineteen recorded from 20 inches upwards, while September and October 1893 were characterised in like manner by very heavy falls of rain.

The only place at which daily meteorological readings are kept is Government House; but it is to be regretted that owing to inaccurate readings and questionable instruments not much reliance can be placed upon them. The thermometer, however, stands highest from July to October, corresponding with the hurricane season, but it cannot be said that the readings are high; the highest dry-bulb thermometer reading at 9 a.m. being only 87°·0.

December, January, February and March are invariably characterised by weather which is exceptionally charming, and which, coupled with scenery of unusual beauty and grandeur, renders Dominica more favoured, as a winter resort during the worst months of the English winter, than any country in the world.

From previous remarks it might be concluded that a superabundance of rain deprives the climate of the island of much of its charm, and lest this idea should gain credence it will be as well to consider some details of the rainfall as recorded at Government House. The figures in Table VII. show that there were 199 days on which any rain was recorded, giving a mean daily fall for each of those days of ·388 ins.; while the total fall amounted to 77·31 ins. or a mean for 366 days of ·211 ins.

There is therefore nothing uncommon or exceptional in the rainfall of Roseau, all things considered; for when evaporation and infiltration within the tropics are taken into account a fall as of anything less than that recorded would in all probability result in a scarcity of water—the greatest curse of any tropical country.

Seismic disturbances are somewhat uncommon, none of importance having occurred for some time past. This fact may, or may not, be due to the existence of a volcanic vent at the Boiling Lake in the Grand Soufrière, the activity of which would indicate the smouldering fires of a former crater. While other islands are frequently visited with shocks of earthquake of greater or less violence, Dominica appears to be more or less exempt from such disturbances.

The last hurricane of importance occurred, as will be seen above, during the month of September 1883, when considerable damage was done throughout the island.

During the hurricane months, which are characterised by calm seas and gentle winds—treacherously calm and gentle—every one lives in almost daily dread of a storm, and a careful watch is kept on the barometer. Public notices appear in the *Gazette* and other papers, cautioning all to be prepared should the signal guns, indicating an approaching storm, be fired. A fall of two-tenths of an inch is held to justify the belief that a disturbance is approaching, and the first gun is then fired. On the further fall of one-tenth of an inch the second gun is fired; and no time is lost in closing up doors and windows, and then awaiting in breathless silence the approach of the storm.

Such was the experience of Sunday, August 30, 1896. The weather had been rainy and boisterous for two or three days previous, and from Friday to Sunday at 3.30 p.m. the barometer had indicated a fall of four-tenths, half of which depression had been recorded from noon on that day. The firing of the signal guns in somewhat rapid succession, caused general activity, and all buildings were tightly closed,

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The Story of the Weather, simply told for General Readers. By GEORGE F. CHAMBERS, F.R.A.S. Sm. 8vo. 232 pp. 1897.

This little book is one of a series of popular books published by George Newnes, Limited. The author states that this work "does not in the least pretend to being a formal treatise on Meteorology regarded as an exact Science, but is merely designed to present in a handy form, and in an unconventional style of language, a certain number of elementary facts, ideas, and suggestions which ordinary people, laying no claims to scientific attainments generally, are usually glad to know."

Waters within the Earth and Laws of Rainflow. By W. S. AUCHINCLOSS, C.E. 43 pp. 8vo. 1897.

The object of the author has been to supply the missing history, and to develop the laws of subterranean flow, or, as he terms it, "rainflow." It is shown that a very large part of the annual rainfall passes away *over* the surface of the ground. Hence the importance of using every means to preserve our forests. For wherever the country is thickly wooded, the undergrowth, ferns, leaves, and mosses arrest the flow of water, to the great benefit of the land; freshets seldom occur, while protracted periods of drought, and failure of springs are scarcely known. The author points out that the withdrawal of a thousand gallons from any well, located in a compact soil, disturbs the ground water level over many acres of ground. It is therefore prudent always to anticipate the encroachments of a growing population by providing an independent water-supply, located far beyond the reach of contaminating influences. This investigation shows the relation between rock- and water-sections; also the analogy existing between the laws of subterranean flow and the laws governing the discharge of water through a weir; the nature and process of recovery, likewise the relation between uniform flow and fading flow. Attention is also directed to the fact that the mean daily temperature of ground water is the same as the yearly average temperature of the air.

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DISCUSSION.

The President (Mr. E. MAWLEY) said that Mr. Bellamy had treated the subject in such a clear and graphic manner that it was easy from his description to form a very good idea of the physical features of the island. Considering the position of Dominica, and that it was only about twice the size of the Isle of Wight, it was surprising to find such a large number of rainfall stations there. The instructions given to observers were sufficiently complete, and had evidently been taken from those issued by Mr. Symons for the benefit of rainfall observers in this country, with certain modifications to adapt them for use in a tropical climate. The observations appeared to be, on the whole, satisfactory. At all events an examination of Table VI., which gave the mean values for four years at five stations, had shown him that the ratios between the monthly and annual falls were remarkably consistent, considering how differently the stations were situated.

Mr. R. JOHNSTONE remarked that he had had experience of Jamaica, whose size was about fourteen times that of Dominica, and position exactly the opposite, lying as it did from east to west instead of north to south as Dominica did; and pointed out how the results obtained in Jamaica compared with those set forth in Mr. Bellamy's paper on Dominica. Mr. Bellamy had stated that the total rainfall of 41 ins. for Batalie for the year 1894 was extremely low for the tropics; but Kingston, Jamacia, had a minimum record of 17½ ins. for a year's fall. He thought it only right to mention, however, that this was exceptionally low compared with that recorded on the opposite side of the island, the difference between the two often being very great. The cool, dry breeze spoken of by Mr. Bellamy was also occasionally felt in Jamaica in the neighbourhood of Kingston, in the shape of what was known as a "Norther," which, however, generally deluged the north side of the island with rain. The Northers were productive of very low temperatures for a tropical island; the lowest readings being generally recorded the day after the breeze had ceased to blow. The minimum for each year at Kingston was usually about 61° or 62°, but the absolute minimum he had known was 56°·7. He agreed with the statement in the paper that "hurricanes" were much less frequent than in former years, in so far at any rate as Jamaica was concerned. In records of a century ago they appeared to be of frequent occurrence and of a very destructive nature, so much so that a fast-day (which afterwards became a public holiday or a holiday for public offices) was instituted by law, and existed up to a short time ago in commemoration of two very bad ones on the same day in different years. The heavy monthly rainfalls given in the paper had been greatly exceeded in Jamaica. At Boston, on the north-east of the island, 95 ins. were recorded in one month, as much as 74 ins. of this falling in one week, and 26 ins. in 22 hours. In the same month the record for Kingston was 32 ins., 27 ins. of which fell in one week. He thought Jamaica had better defined rainy seasons as compared with Dominica, and instanced the chief characteristics of the Jamaica rainfall. In conclusion, he thought that all the advantages that had been claimed for Dominica in the way of pleasant climate, cool nights, and such matters, could also be found in Jamaica, and perhaps in even a more marked degree.

Mr. J. A. CURTIS said that on looking up the rainfall figures for Barbados, he found a large excess at Dominica as compared with that place. The mean rainfall at Barbados for 29 years was 50 ins., the highest yearly total in that period being 76·35 ins. in 1867, and the maximum fall on one day 11·75 ins., in September 1875. He had been able to find only two years' records for Antigua, and the mean of these gave a yearly rainfall of 56 ins.

Mr. H. N. DICKSON thought the paper of great value. A steady wind on a simple surface was productive of rainfall, but the conditions in the case of hilly districts were generally so complex that it was impossible to arrive at the variation for differents heights. He thought the systematic investigation of the rainfall of the West Indian Islands would be of great value in the elucidation of the question as to whether the density of sea-water was at all affected by rainfall, to which the Dutch Government had devoted much attention, notably in the East Indies.

Dr. R. BOWLES said he had always understood that in Alpine and other mountainous districts the precipitation occurred on the opposite side of the mountains to that met by the air current, but in the case of Dominica, the reverse seemed to be the case. Was this due to some purely local influence?

Hon. F. A. R. RUSSELL said that the author had stated that there was little variation in the direction of the wind, which was the ordinary Trade-wind, but he had omitted to mention the exact direction. The statement by Mr. Bellamy that the Trade-wind, after being deprived of its moisture by condensation, became cooler, deserved particular notice, for a very large condensation of moisture was generally held to produce a strong heating effect upon the air which has crossed over mountains, the warm Föhn wind of the Alps for instance being explained by the liberation of the heat of condensed vapour.

Mr. G. J. SYMONS highly appreciated the work done by Mr. Bellamy. Observations of temperature and humidity would undoubtedly add greatly to the value of the records. Mr. Bellamy had referred in the paper to means extending from 10 to 20 years for some of the stations, and he (Mr. Symons) thought that a real service would be done if these records of the island could be exhumed and treated in the same way as the four years under discussion, which were, he believed, all the meteorological statistics they yet possessed of the island of Dominica.

Mr. R. H. SCOTT said that the fundamental principal of rainfall in mountainous districts was that the precipitation occurred on the weather side, the lee side being much drier. The eastern peaks of the Andes were constantly covered by cloud, as the South-east Trade-wind of the South Atlantic, which came over the plains of Brazil, was forced to ascend when it met the Andes, and deposited its moisture on their "weather" slopes.

MEANS OF THE DAILY MINIMUM, DAILY AVERAGE, AND DAILY MAXIMUM TEMPERATURES AS RECORDED AT THE STATIONS INCLUDED IN THE *Daily* AND *Weekly Weather Reports*, DURING THE 25 YEARS 1871-95.

BY ROBERT H. SCOTT, M.A., F.R.S., AND FREDERIC GASTER, F.R.Met.Soc.

[Read May 19, 1897.]

IN the preface to the *Weekly Weather Report* 1895, and the *Daily Weather Report* 1896, part ii., issued by the Meteorological Council, a set of Means of Temperature, Rainfall, and Bright Sunshine have been recently published, which deserve to be more generally known than they are,—especially as the light which they throw on the weather prevailing over various parts of the British Isles from time to time is important and almost unique. It is the object of this paper to bring out prominently some of these details with regard to Temperature, leaving for further consideration those for Rainfall and Bright Sunshine—as more information on these subjects is in course of preparation, and much of it is already in the press.

The Temperature Tables give—for each month in the year, and for the stations mentioned, (in all 74 in number, and well distributed over the United Kingdom)—the mean values for the daily minimum, average, and maximum temperatures of the air, and, for a certain number of them, the absolute extremes which have been recorded at each station during the 25 years 1871-95.

Other works on the mean temperature for each month have already appeared—notably those published by Dr. A. Buchan in the *Journal of the Scottish Meteorological Society*, vol. vi. p. 22 (referring to the means of the daily average values only), and later on by Mr. F. C. Bayard (*Quarterly Journal*, vol. xviii. p. 213); these latter observations were made almost exclusively at English stations, and the period (1881-90) covered was scarcely so long as could have been desired. In the year 1891 the Meteorological Office also published a set of values very similar to those now to be discussed, but the addition of another lustrum to the period then embraced has not only increased the weight to be attached to the information, but has rendered possible the filling up of many blanks which at that time were unavoidable.

The original object in publishing the series now under notice was to furnish mean values with which the current readings given in the *Daily* and *Weekly Weather Reports* might be compared, and the methods employed in their preparation are stated at the foot of the tables. It is believed to be the first occasion on which the means of the daily maxima and minima for each month have been dealt with at all fully; and certainly the first in which the absolute extremes for each station and for so long a period have been submitted to the public, together with the dates on which they occurred. It is for these reasons that special attention is called to them, as they present, with regard to climate, features that are calculated to provoke still further and more minute investigation, not only into the conditions prevailing over the British Isles, but over the Continent, and, it may be added, over all other parts of the world. The results should likewise encourage observers to be constantly on the alert to ensure accuracy in their instruments, uniformity of exposure, and extreme care in their methods of reading and recording the indications—especially when it is seen how minute are some of the differences which point to really important physical phenomena.

It will be impossible to deal at all fully in one paper with the subject, even when it is limited as stated above; it is proposed, therefore, if the present effort should prove acceptable, to develop the matter more fully in another paper to be submitted to the Society early in next session.

It should be stated that by far the majority of the stations from which these values have been received have records extending over the whole period of 25 years. In cases for which the record was not complete the approximate readings were obtained by interpolation, and, in the first portion of the work, stations whose record did not amount to at least 10 years[1] were rejected. Maps were then drawn showing for each month in the 10 years, 1886-95, the distribution of the temperature at the time of the minimum, average, and maximum values. The stations available were numerous, and showed the distribution very fairly. Similar maps for the 25 years, 1871-95, were then drawn, but the information for this long period being scarcely so full, the general *trend* of the isotherm shown by the shorter series was adhered to very closely in the regions not well represented by the longer series.

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[1] This has accidentally been printed as "11 years" at the foot of the tables in the *Weekly Weather Report*.

It was in the preparation of these maps that the features to which attention is about to be directed were developed so clearly, that the advisability of placing them before the Society was considered desirable, and the preparation of the necessary paper was undertaken The calculation and plotting of the mean values, therefore, was, in the first case, an official undertaking for the internal work of the Meteorological Office, but it was found that the results were too interesting to be withheld from meteorologists generally. There is no pretence that this investigation is final, but it is submitted mainly to show the importance of continuing this class of work in greater detail, so that the conclusions arrived at may be either fully established, or, if necessary, put on one side as not supported by further and wider information.

In considering the tables, it will be found that the Mean Daily temperature of the air is, as a whole, lowest in January and highest in July; and that the transition from one of these conditions to the other is fairly uniform. But even thus early, we find that there is a great difference between the amplitude of the range at the coast (and especially the south-west coast) stations and that observed inland—the coast statistics, and especially the western ones, being both warmer in winter and cooler in summer than those over the inland counties. Nor is this all, for the daily range also (from the time of the daily minimum to that of the maximum) is decidedly greater at the inland than at the coast stations. Two brief tables will be sufficient to show these characteristics clearly—not that the facts have not been already dwelt on by other writers on temperature, but because its repetition is necessary as a basis from which further advance may be made, and in order that the reader may be spared the trouble of research into the earlier works for the proof of the law here quoted.

TABLE I.—MEAN TEMPERATURE OF THE AIR, AND ALSO THE MEAN ANNUAL RANGE IN JANUARY AND JULY AT SOME OF THE INLAND AND COAST STATIONS OF THE BRITISH ISLANDS FOR THE TWENTY-FIVE YEARS 1871-95.

Coast Stations.				Inland Stations.			
Stations.	Jan.	July.	Range.	Stations.	Jan.	July.	Range.
	°	°	°		°	°	°
Stornoway .	38·5	54·6	16·1	Braemar . .	34·0	54·9	20·9
Belmullet . .	42·6	58·0	15·4	Parsonstown .	39·3	58·8	19·5
Valencia . .	44·4	58·8	14·4	Loughborough .	37·1	61·8	24·7
Scilly . . .	45·4	60·3	14·9	Oxford . .	37·7	61·4	23·7
Hurst Castle .	40·0	61·6	21·6	Cambridge . .	36·8	61·9	25·1
Yarmouth . .	37·0	60·5	23·5	London . .	38·3	63·0	24·7
Shields . .	38·1	57·9	19·8	Strathfield Turgiss	37·1	61·7	24·6
Aberdeen . .	37·4	57·2	19·8	Southampton .	39·2	62·3	23·1
Mean Annual Range. .			18·2	Mean Annual Range. .			23·3

TABLE II.—MEAN DAILY RANGE OF TEMPERATURE AT SOME COAST AND INLAND STATIONS IN THE BRITISH ISLANDS DURING THE MONTHS OF JANUARY AND JULY FOR THE TWENTY-FIVE YEARS 1871-95.

JANUARY.				JULY.			
Coast Stations.		Inland Stations.		Coast Stations.		Inland Stations.	
Stations.	Daily Range.	Stations.	Daily Range.	Stations.	Daily Range.	Stations.	Daily Range.
Stornoway .	8°·9	Braemar .	10°·9	Stornoway .	11°·2	Braemar .	15°·4
Belmullet .	7·7	Parsonstown	11·4	Belmullet .	18·4	Parsonstown	14·8
Valencia .	9·2	Loughboro'	10·5	Valencia .	10·3	Loughboro'	19·6
Scilly . .	6·2	Oxford .	9·6	Scilly . .	8·2	Oxford .	16·1
Hurst Castle	8·8	Cambridge .	11·8	Hurst Castle	12·2	Cambridge .	19·5
Yarmouth .	7·9	London .	10·2	Yarmouth .	11·4	London .	18·0
Shields .	9·2	Strathfield Turgiss .	11·2	Shields .	12·0	Strathfield Turgiss .	20·2
Aberdeen .	9·2	Southampton	9·3	Aberdeen .	12·9	Southampton	16·1

By these figures the facts mentioned are abundantly shown. We have in Table I. a mean annual range of temperature amounting to 18°·2 at the coast, and to 23°·3 at the inland stations; while the values for individual stations vary among themselves from less than 15° at Valencia and Scilly, to more than 25° at Cambridge. From Table II. it appears that the diurnal range varies in January from 6°·2 in the Scilly Islands to more than 11° at Parsonstown, Cambridge, and Strathfield Turgiss; and in July from 8°·2 at the Scilly Islands to between 19°·5 and 20°·2 at the inland English stations quoted above.

Before going further it will be desirable to consider what are the causes on which these changes and the variations in their intensity depend. The source of almost all the heat which reaches us is the sun. The effect of the solar rays in heating the atmosphere as they pass through it, is too small to be considered in a paper like this—so that we may take it that the sun's heat is first of all spent in warming the earth's surface, which in its turn communicates the heat to the air by contact. Two main causes of variation in the amount of heat so received have to be remembered: first, the difference between the length of the daytime and the angle of incidence of the solar rays in the winter and the summer seasons respectively; and secondly, the fact that at all parts of the year there are the alternations of day and night. It must then be remembered that the constant effort of the earth is to radiate into space the heat which it so receives. It is therefore evident that as the daytime increases in length, and the solar rays in intensity, the temperature of the earth, and consequently that of the air, increases decidedly; while as winter comes on and the daytime becomes shorter, and the solar rays reach us more obliquely, the earth parts with its heat more rapidly than it receives it, and the temperature falls.[1]

Then again, if we remember that the land both absorbs and parts with the solar heat much more readily than the sea, we shall see that in the summer time the land and the air over it would naturally be warmer than the sea, while in winter the land would become the colder of the two; so also with regard to the day and night—the land would be the warmer of the two during the day and the cooler of the two at night, but the amount of difference would vary at different seasons.

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[1] Both of these changes are of course modified greatly by the alterations in the prevalence of cloud and vapour in the air; but as we are dealing now with mean values only, these modifications may be neglected for the present.

Let us now examine the various maps showing the distribution of mean daily temperature in the months of January and July (Figs. 1 and 2).

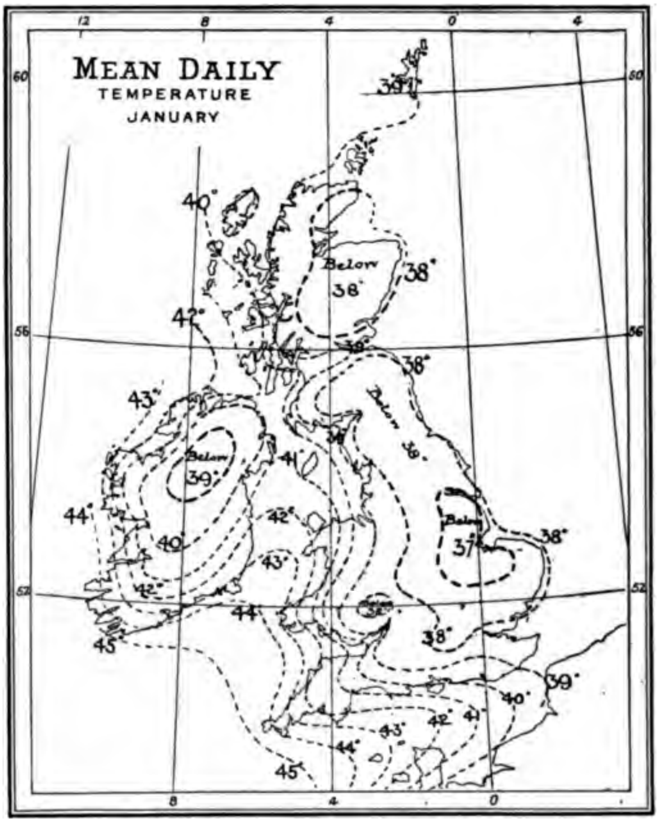

FIG. 1.

It is seen that in January the mean temperature of the air (when due allowance has been made for the altitude of each station above the mean sea-level[1]) ranges from 43° and 45° along the western and southern coasts of Ireland and the south-western coasts of England, to rather below 39° over the inland parts of the north of Ireland, to rather less than 38° over the inland and eastern parts of Scotland and the greater part of England, and to less than 37° over Lincolnshire, Bedfordshire, and parts of Cambridge and Norfolk. The eastern and north-eastern coasts of England and the north-east of Ireland are very little warmer than the inland parts of the country, but the western coasts are warmer by 7° or 8°. But the main feature is that of warm air on the coasts and cold air over the land—the difference between the intensity of the phenomenon in the west and in the east being left for consideration later on.

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[1] The value used in preparing this paper has been at the rate of 1° Fahr. for each 300 feet of elevation.

Turning now to the map showing the distribution of mean daily temperature in July (Fig. 2), we find the condition completely reversed. The inland parts of the islands are now the areas of greatest heat; while the coasts, and especially the western and south-western coasts, are the cooler regions. In this case also the thermic gradient, *i.e.* the amount of difference in temperature for a given unit of distance, is much steeper over the western than over the eastern and north-eastern parts of each country; but the main feature is that of high inland and low coast temperatures.

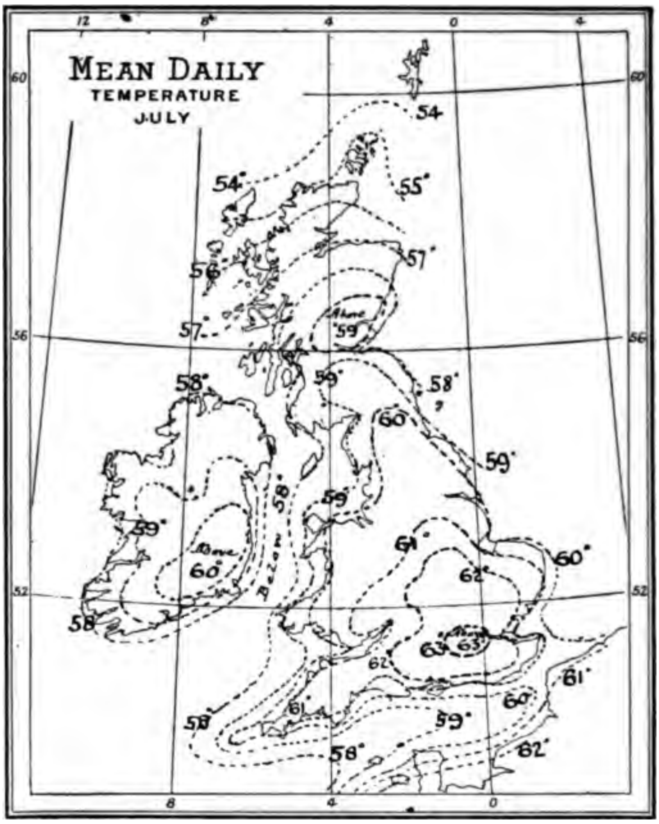


Fig. 2.

In order to facilitate the work of reference, it is proposed to term the feature of *high coast* and *low inland* temperatures as the "Winter Type" of distribution, and the *low coast* and *high inland* temperatures as the "Summer Type." On examining the maps showing the mean daily

TABLE III.—Monthly Rainfall in Dominica, 1895.

Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Batalie	0·77	0·27	2·30	0·80	11·31	4·43	5·20	11·24	14·02	9·72	14·77	4·57	79·40
Bath	4·93	1·00	5·21	2·86	10·09	2·38	6·22	12·36	15·82	10·70	12·64	5·40	89·61
Botanical Station	4·03	1·09	5·35	2·92	10·08	3·19	7·13	9·67	17·42	11·32	11·21	5·66	89·07
Castle Bruce	15·88	2·98	5·89	9·59	12·99	4·67	7·47	12·66	24·83	18·34	15·78	36·61	167·69
Geneva	9·26	3·82	9·58	9·65	16·35	4·18	8·55	15·15	21·50	19·05	13·50	16·40	146·99
Hampstead	7·55	1·26	2·86	6·70	12·14	4·81	5·89	14·15	20·00	19·34	13·84	16·34	124·88
Hatton Hall	9·31	2·86	7·03	7·20	13·38	6·19	7·94	16·80	17·64	14·51	22·67	6·38	131·91
La Haut	...	...	...	...	...	...	3·30	6·10	7·88	5·74	8·53	2·95	Incomp.
Malgretout	7·52	2·50	6·50	10·08	19·78	5·90	10·35	14·30	28·23	19·47	22·54	12·97	160·14
Melville Hall	4·83	2·24	2·03	5·91	13·81	4·46	6·10	12·75	21·38	23·02	14·59	30·00	141·12
Point Mulatre	20·00	3·27	4·18	8·39	15·39	3·98	6·45	14·15	21·10	20·00	16·42	16·06	149·39
Rosalie	15·09	2·66	3·41	9·59	19·62	5·77	7·97	15·34	28·09	21·65	14·78	24·25	168·22
St. Aroment	6·78	1·65	8·35	4·83	13·65	4·79	8·92	11·70	20·70	15·84	16·96	7·07	121·24
St. Sauveur	13·01	2·88	2·90	7·35	23·31	3·43	8·60	11·17	28·29	17·96	15·76	30·44	165·10
Shawford	13·53	3·89	13·45	10·63	30·05	12·63	16·72	24·95	35·93	22·34	34·69	15·86	234·67
Souffrière	6·19	2·38	5·01	9·63	19·34	3·58	6·42	11·96	21·28	13·87	8·37	8·90	116·93
Training School	4·38	1·12	5·67	2·96	11·78	2·82	7·82	9·00	15·95	11·26	12·14	5·54	90·44
Wall House	5·22	3·84	7·03	17·71	4·49	3·25	7·05	14·61	20·09	12·29	14·33	6·29	116·20
Woodford Hill	8·41	1·33	1·84	6·86	6·71	1·31	3·96	12·01	13·29	18·07	10·55	31·23	115·57

TABLE IV.—Monthly Rainfall in Dominica, 1896.

Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Batalie	3·74	0·55	1·36	1·96	4·87	8·96	12·50	6·66	7·38	9·41	19·28	3·38	80·05
Bath	5·45	0·70	2·93	1·22	6·28	8·50	15·43	6·61	6·07	4·28	19·29	4·13	80·89
Botanical Station	5·52	1·23	2·73	1·27	6·12	8·23	14·88	7·07	6·47	3·93	16·81	6·60	80·86
Castle Bruce	9·10	4·48	3·64	12·08	20·04	10·46	13·08	9·23	10·96	9·60	59·09	21·67	183·43
Geneva	7·35	4·52	3·70	8·20	17·82	6·21	18·35	13·80	11·66	9·45	22·00	10·65	133·71
Goodwill	4·98	1·11	2·00	1·00	5·90	8·70	14·70	6·46	5·77	3·74	17·65	3·26	75·27
Gov. Ho., Roseau	6·77	0·88	2·03	0·99	4·89	7·99	14·36	6·82	5·92	3·82	18·77	4·07	77·31
Hampstead	8·60	2·90	3·03	5·33	5·07	4·28	16·83	7·48	8·22	6·16	41·45	9·18	118·53
Hatton Hall	6·76	5·51	4·59	7·44	10·75	12·42	18·71	8·94	6·09	2·40	20·80	8·93	113·34
La Haut	6·38	1·58	3·43	2·45	8·02	10·20	16·18	8·76	7·68	3·88	21·08	7·27	96·91
Londonderry	...	...	...	...	...	...	...	...	5·63	16·48	53·62	7·96	Incomp.
Malgretout	7·90	4·90	5·55	3·61	11·05	10·98	21·30	12·18	14·81	5·86	25·47	10·65	134·26
Melville Hall	9·60	4·87	1·75	8·67	14·68	10·97	10·52	10·66	10·25	11·03	53·51	10·60	157·11
Point Mulatre	8·38	3·08	2·48	9·84	19·27	11·13	14·29	12·36	16·36	8·14	49·02	8·47	162·82
Portsmouth	...	...	...	...	...	...	21·88	7·19	7·62	5·29	25·46	8·19	Incomp.
Rosalie	10·85	2·67	3·03	14·65	20·21	12·93	16·05	10·47	12·78	10·86	76·85	10·72	202·07
St. Aroment	6·41	1·74	5·29	2·21	7·57	10·01	19·00	8·91	7·97	6·30	25·20	5·62	106·23
St. Sauveur	11·71	3·68	3·74	14·95	27·29	16·22	11·66	10·37	12·16	15·08	71·57	11·59	210·02
Shawford	12·37	5·66	10·55	9·40	15·29	14·96	32·37	16·93	13·12	8·74	36·60	14·81	190·80
Souffrière	6·23	1·68	2·00	3·83	7·56	8·03	12·06	9·31	10·83	8·42	19·69	9·64	99·28
Wall House	5·47	1·65	2·63	2·10	5·82	8·69	16·52	8·07	6·62	4·49	13·00	5·39	80·45
Woodford Hill	52·4	3·36	1·55	6·26	13·68	6·96	9·75	8·57	10·08	9·03	50·85	6·44	131·77

diurnal cold) are acting in conjunction; and the land being more amenable to their influence than the sea, the difference between the temperature of these two surfaces, or, in other words, the winter distribution, is shown in its greatest intensity.

In the next map (Fig. 4) showing the distribution at the time of the mean daily *maximum* in this same month, the thermic gradients are very slight, the reason being that the causes of winter cold are being counteracted by the solar rays, and the winter type of distribution is therefore modified to some extent. The thermic gradients are slight even over the western and southern parts of the kingdom, while in the northeast and east there is no difference to be seen—the coast stations in those regions being in fact the coldest of all. These and some other features in those maps will be referred to further on.

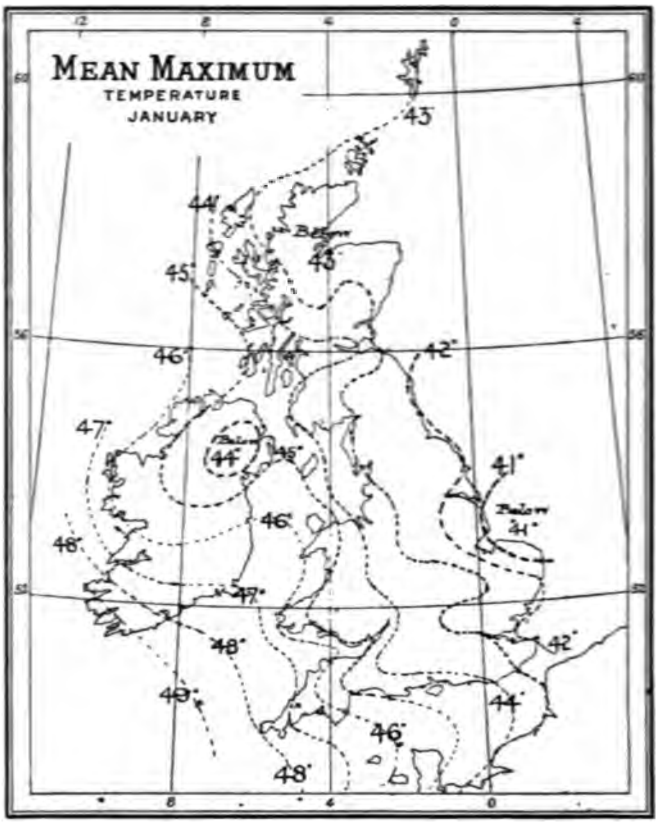


FIG. 4.

Having dealt with the most winterly type of maps, let us examine those for the warmest month of the year, viz. July. These will be found in Figs. 5 and 6 (p. 284). Taking Fig. 5, that showing the distribution at the time of the daily *minimum*, a time when the influence of the summer heat is being counteracted by the cold of night, we find that at this hour the latter tendency is powerful enough to overcome the former to a very large extent, so that over central Scotland, the northern parts of England, Wales and Ireland, the winter type of distribution is still prevalent, but its intensity much reduced, the thermic gradients being slight, and irregular in places. Over the south-east of England and our south midland counties, however, the summer distribution is developed weakly and very locally.

The chart for the time of the *maximum* (Fig. 6, p. 284), however, is very different. The heating tendency of the summer sun, and that of the long days, are found to produce the most interesting map we have so far dealt with. The excess of the inland temperatures over those on the coast is very strongly marked, and the thermic gradients are very steep—even over the southern and eastern counties of England. There is a difference between the mean maximum in London and that at Hastings of 5°; between those of Southampton and Hurst Castle of 3°; and between those of Durham and Shields of 5°; and there can be little doubt that were the requisite information available, it would turn out that the differences really occur in a much shorter distance. In this map also there are other important

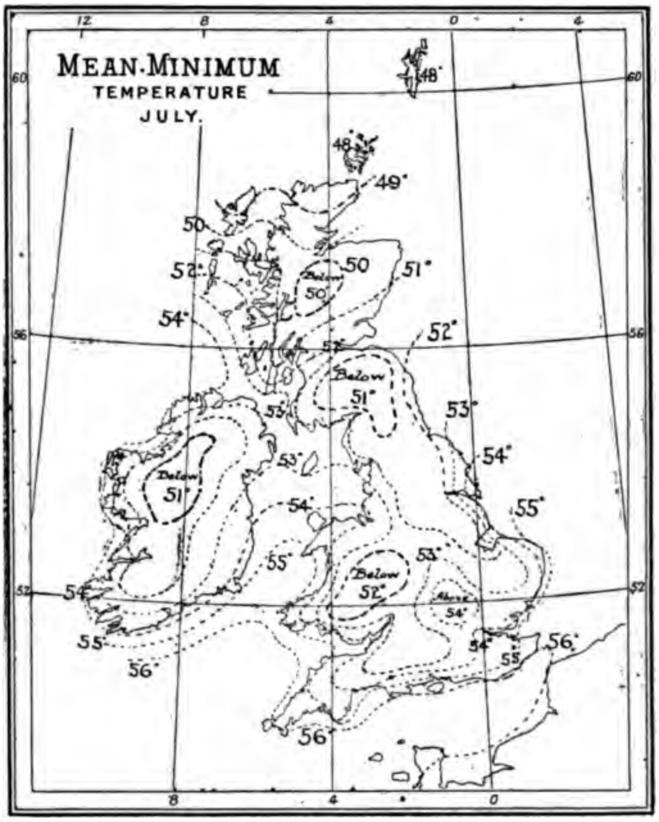


Fig. 5.

features which are touched on later in this paper; but before proceeding to them it will be well to summarise the facts arrived at so far. Thus, it appears that—

1. The mean daily temperature of the air over the British Isles is lowest in January and highest in July, the range being much greater inland than on the coast. The distribution of temperature is of two distinct types—one in which the inland temperatures are lower than those on the coasts, and called the "Winter Type" of distribution; the other in which the inland values are high and the coast values low, and called the "Summer Type." The first of these types prevails during the winter half of the year, but gives way to the second some time in April; but again asserts itself in some part of October.

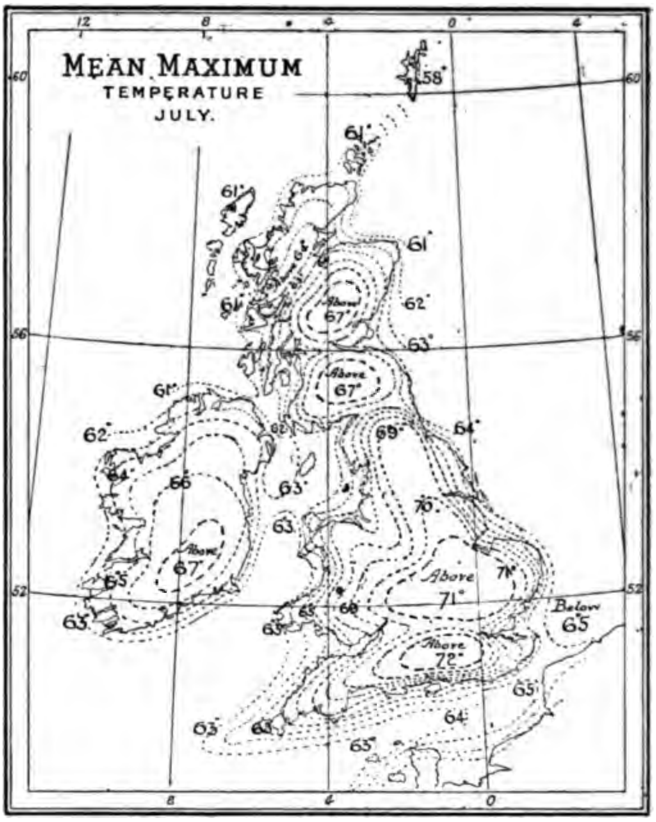


FIG. 6.

2. At the time of the mean daily *minimum* the distribution of temperature is in all months that of the "Winter Type." It is most strongly marked in the middle of winter, decreases in intensity until July, when it is very slight; but is never quite obliterated, except over a portion of the south-eastern parts of England, in July.

3. At the time of the daily *maximum* temperature the distribution in

almost all months is that of the "Summer Type." It is most strongly marked in midsummer, but decreases in intensity as winter approaches, and is not traceable in January.

We have next to notice some other features of a most interesting kind, and to which attention has not, so far as we are aware, been previously drawn. It will be seen on examining the map showing the maximum temperature in July that in addition to the fact of the summer type of distribution being so strongly marked, there are certain bands lying across the country in which the values are scarcely so high as in the regions on each side of them. Three of these bands lie from west-south-west to east-north-east, one following the valley of the Severn for a certain distance, and then the valley of the Thames, and stretching right across the country; the other follows the valley across the north of England from the Solway to the Tyne; while the third passes across Scotland along the Forth and Clyde valleys. There is a fourth band, running from south-south-west to north-north-east over Scotland, following the route of the Caledonian Canal, and a partial development of a similar kind is observed over the valley of the Mersey, stretching a considerable distance inland. The simplest explanation of this phenomenon seems to be the following. The sea is at this time of the year much cooler than the land, and as the general direction of the wind is from between West and South-west, that portion of the air which passes with little obstruction along the valleys carries with it some of the coolness of the ocean from over which it has been drawn; while that on either side of the valley is stopped by the hills, and by longer contact with the heated earth becomes much warmer than that in the valleys. No doubt some of the effect may be due to the water in the rivers too, but over much of the distance the volume of water in the rivers is too small to be taken into account. In all the charts showing the distribution of maximum temperature from April to August these features come out strongly, but in October and the winter months they are not traceable.

If the explanation here offered is the right one, then we should find in the winter time bands of warmer air occupying the position which those of cool air do in summer; and this is found to be so. Although in the map (Fig. 3), showing the distribution of temperature at the time of the minimum in January, these bands of warm air are not complete, the tendency to them is distinctly seen, and in those of December and some of the other winter months they are much more clearly defined.

Before concluding this paper, some reference should be made to the facts in the chart showing the distribution of mean *maximum* temperature in January, viz. that the coldest parts of England are its extreme eastern, not its inland counties; and that at the time of mean *minimum* in July there is a definite, though weak tendency to summer type of distribution, although over Scotland, the north of England, Wales, and Ireland the winter type prevails; and, finally, that the inland areas of warmth in summer time do not appear to occupy exactly the same positions that the areas of cold do in winter. This will be inquired into on a future occasion. Enough has been said even here to show what interesting and important features are brought to light by the discussion of the returns from even a few stations. There can be no doubt that by including returns from a larger number of stations, the phenomena will be still more clearly defined, and that other features will come to light—possibly of still greater interest.

It is proposed, however, before dealing with such further subjects to go a little deeper into this matter of the influence of river valleys with materials already to hand, and to discuss the question of the conditions under which some of the extremes, both of cold and heat, have been recorded, and, if possible, to see what effect river valleys may have on the humidity of the air. It is doubtful, however, whether this can be properly dealt with for some considerable time, as the labour required will be considerable.

DISCUSSION.

The President (Mr. E. Mawley) considered this a very valuable paper, owing to the long period—a quarter of a century—over which the records extended—upon which it had been based. For the same reason it was much in advance of any previous discussion of the same subject, and the Fellows would look forward with considerable interest to the appearance of the paper which the authors had promised them in continuation of the present one.

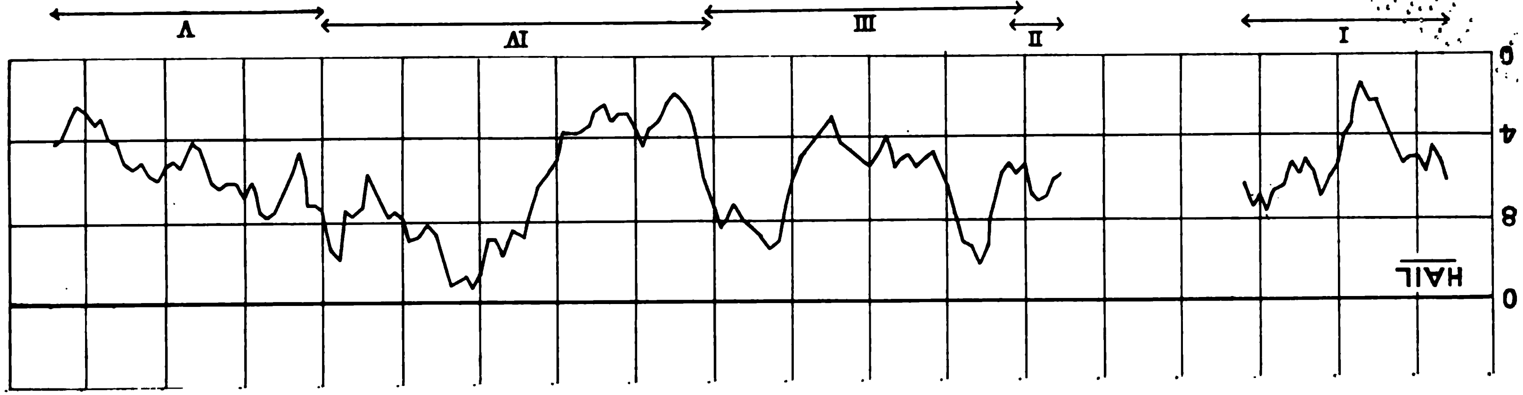
Dr. C. T. Williams said there was no doubt that the paper was a valuable contribution, as all the facts and features had been shown in a most useful form. For himself, he had no idea that the range between inland and coast stations was so marked. Of course the warm waters of the equatorial current would tend to raise the temperature of the western coasts, while its effect on our eastern shores would be comparatively small, and on one part of Norfolk almost nil; but even that could not account for the difference of range which was shown to be so strongly marked. Mr. Gaster's illustration of how the warm air rushed up the valleys where it was not held in check by high ground satisfactorily explained what he (Dr. Williams) had so often noticed in England, viz. that a series of belts extended across the country where vegetation was always abnormally forward in comparison with the adjacent country.

Mr. H. N. Dickson said that in drawing a rough chart of temperature some three or four years ago, a specially noticeable feature was that in all cases where the coast-line ceased to be mountainous the temperature became warmer directly inland. Plains on the lee side of mountains had often great range of temperature. He had noticed when there was an excess of fresh water on the surface of the North Sea it was followed by a hard winter here; but on the other hand, when drift currents were unusually strong, it seemed to constitute a defence against the high-pressure systems lying over the continent which produce the cold.

Mr. H. Southall said the influx of warm air up the Severn valley, and its influence on vegetation, etc., had long been observed in the neighbourhood where he resided, but the paper gave a satisfactory explanation of various anomalies which had long puzzled him.

Mr. R. H. Scott said that the paper was not intended to advance any theory, but dealt simply with the figures which had appeared in the *Weekly Weather Report* for 1895. He should be glad to know if Mr. Dickson could suggest any way in which continental influence on our weather could be traced satisfactorily.

Mr. F. Gaster said, in reply, that in winter, the prevalent wind being Westerly, the eastern side of the country was markedly colder than the western,


HAIL
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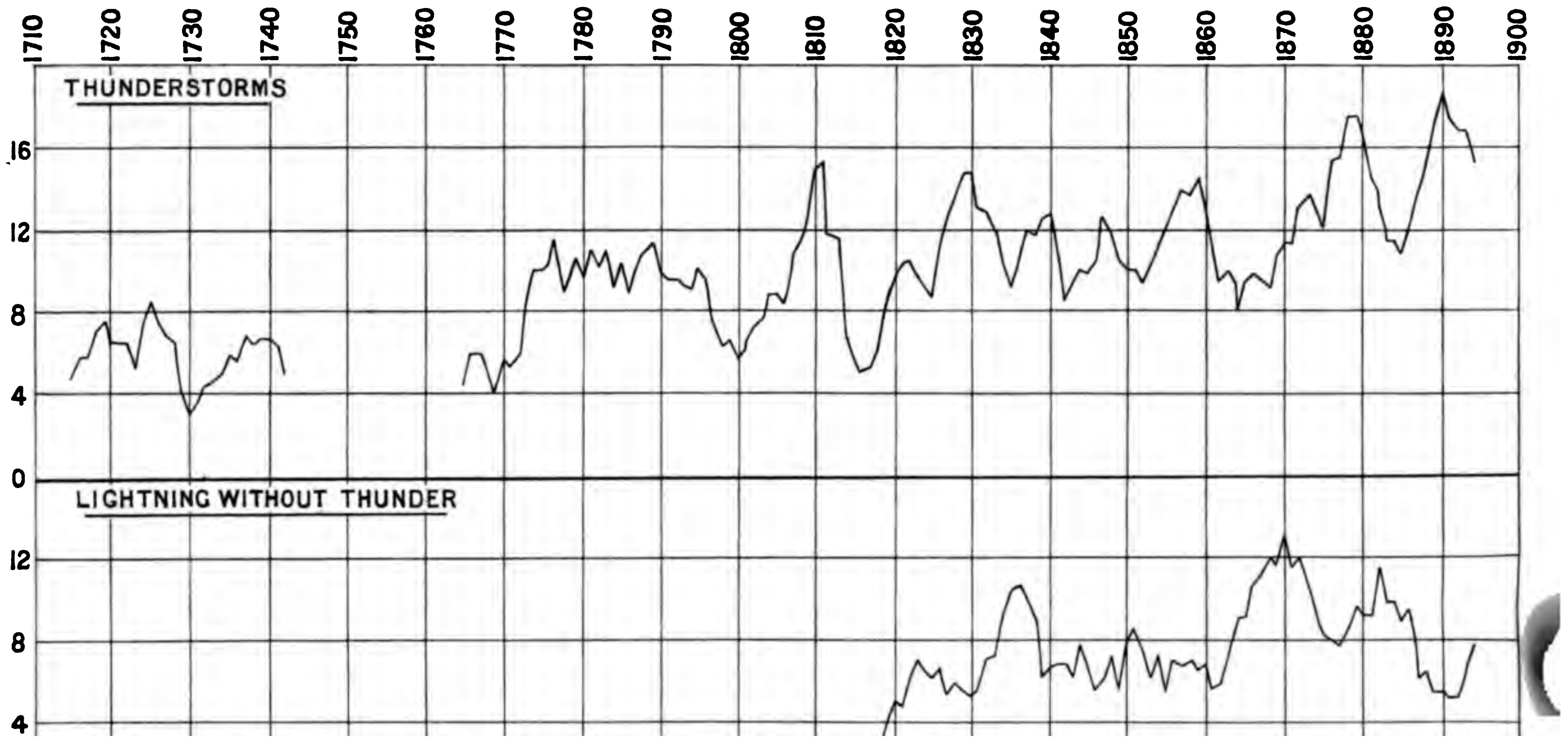
NUMBER OF DAYS PER ANNUM OF EACH PHENOMENON.



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as the temperature of the air became very much lower during its progress over the land. With regard to what Mr. Dickson had said, it would be necessary to re-total the figures, grouping them with special reference to the direction of the wind. We could thus trace an important continental influence, and many other features would come out more strongly. Another grouping under clear and dull weather would yield valuable results. The matter was certainly worth considering, although the work would be heavy.

THE NON-INSTRUMENTAL METEOROLOGY OF LONDON, 1713–1896.

By R. C. MOSSMAN, F.R.S.E., F.R.Met.Soc.

(Plate VI.)

[Read June 16, 1897.]

BEFORE giving the results of this investigation it may be as well to point out that the above title, which has been adopted for the sake of brevity, is a little misleading, for the following reasons:—(1) The phenomena discussed have been restricted to notices of snow, hail, gales, thunderstorms, lightning without thunder, and fog. Cases of halos, haze, dew, hoar-frost, etc., have been excluded, as these were not systematically noted during the greater part of the period under review. (2) Very few observations were actually made in the metropolis, the stations being either Kew or Greenwich, except for the 20 years, 1763-1782. (3) There is a hiatus from 1758-1762, and during 1746. From 1747 to 1758 the data have been obtained from a daily record of the weather given monthly in the *London Magazine*, which from its extreme brevity is necessarily imperfect. The values for this period are not included in the general tables.

The data down to 1855 were obtained from meteorological registers in manuscript, kindly lent by the Royal Meteorological Society and the Scottish Meteorological Society. They include the following:—

I. Register kept at Richmond, Surrey, from April 1713 to June 1745, by Mr. George Smith, a Proctor to Queen Anne. The dates, being those of the old style, have been corrected by the addition of eleven days, so as to bring them into agreement with the system of chronology introduced on September 2, 1752.

II. *The London Magazine* record, referred to above.

III. Register printed monthly in the *Gentleman's Magazine*, 1763-1771. The station from November to April was near the north bank of the Thames, just below London Bridge. During the other half of the year the station was situated seven miles west of Hyde Park Corner. I have been unable to ascertain the name of the observer.

IV. Register kept by Mr. Thomas Hoy at the following places:—Kennington, 1771-1774; Muswell Hill, 1775-1782; and Sion House, near Kew, 1783-1822. This record was utilised till the commencement of Belville's observations.

V. Register kept at Greenwich by Mr. John Henry Belville from March 1, 1811, to July 7, 1856.

VI. Daily weather notes from Greenwich Observatory, published in the Registrar-General's *Weekly Return of Births, Marriages, and Deaths*, 1855-1896.

The remarks on the state of the weather were examined for each of the 65,000 days covered by the investigation, and the symbols entered along with the direction of the wind on forms ruled for each day in the year. The phenomena were then classified and the results entered in the tables appended to the paper.[1] The analysis so far has been restricted to monthly and annual values, but I hope in another paper to give means for each day in the year. The bearing of the direction of the wind on the phenomena under discussion will also form a subject for future investigation. Decennial means, however, are given in the following tables.

Every effort has been made to eliminate error, but as there are over 13,000 entries it would be sanguine to imagine that no omissions have been made.

It must be admitted that great difficulty is found in attempting to compare various sets of observations: so much depends on the position of the station and on the fluctuating error due to the personal equation of the observer. Thus, for example, one observer would enter snow when only a few flakes fell, while another would perhaps omit to record such a trivial occurrence. Each register is doubtless comparable *inter se.* In order to place the facts in a clear light the annual values have been smoothed by making continuous five-year groups, the results being graphically delineated in the diagrams on Plate VI. On the suggestion of Mr. Symons the commencement and termination of each register are indicated at the foot of the diagrams. In this way the effect of a change in the observer may be approximately ascertained. In view of the many difficulties which attend any discussion of the observations treated as one homogeneous whole, I shall confine my remarks to a few broad generalisations on some of the more prominent results of the inquiry. The periods discussed are the 33 years ending June 1745, and the 134 years, 1763-1896—167 years in all.

Thunderstorms.

The total number of thunderstorms observed was 1618, an average of 9·7 per annum. The maximum was in 1878 and 1880, when 25 were recorded, and the minimum was 1 in 1729. The maximum in one month was 12 in June 1726, while in July 1880 11 thunderstorms were observed. The annual period is well marked, embracing the six months April to September, during which time 91·5 per cent of the whole took place. The maximum occurs in July with 406 cases, and the minimum in February, with 7. The total number observed in each month and the percentage frequency are as follows:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Total . . .	12	7	23	106	215	307	406	304	143	49	26	20
Per cent . .	0·8	0·4	1·4	6·6	13·3	19·0	25·1	18·8	8·8	3·0	1·6	1·2

The smoothed annual values are shown in Fig. 1 (Plate VI). It will be seen that there has been a pretty steady increase in the frequency of thunderstorms during nearly the whole time. This fact is also apparent from the reduction of the Edinburgh observations[2] extending over more than a century and a quarter, and can hardly be accounted for by the assumption that the observers are more careful now than formerly. The eleven-year period comes out fairly well in the Greenwich set, there being maxima in 1811, 1822, 1830, 1840, 1847, 1859, 1873, 1879, and 1890; and minima in 1816, 1825, 1835, 1842, 1852, 1864, 1875, and 1885. I have no intention in this paper of entering on the question of weather cycles, but hope those who have made this interesting, but unsatisfactory, subject peculiarly their own will consider the data worthy of discussion in this connection.

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[1] These long tables of monthly values are not printed herewith, but they are in the possession of the Society.

[2] *Trans. Roy. Soc. Edin.*, vol. xxxix. p. 1.

TABLE I.—Days of Thunderstorms. Decennial Means.

Decades.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1721–30	0·1	...	...	0·3	1·1	**1·8**	0·9	0·5	0·3	0·1	...	0·1	5·2
1731–40	0·1	...	...	0·3	1·2	0·8	**1·4**	0·9	0·6	0·1	...	0·1	5·5
1771–80	...	...	0·3	0·4	0·9	**2·0**	1·7	1·0	1·8	0·5	0·3	...	8·9
1781–90	...	0·1	0·1	0·2	1·5	**2·6**	**2·6**	**2·6**	0·9	0·2	0·1	0·1	11·0
1791–00	0·1	...	0·1	0·9	0·7	1·2	1·7	**2·2**	0·5	0·3	0·2	...	7·9
1801–10	0·1	...	0·2	0·5	0·6	1·5	**3·6**	2·1	0·6	0·2	0·1	...	9·5
1811–20	...	0·3	0·3	0·3	**2·1**	1·7	1·8	0·9	0·5	0·2	0·2	...	8·3
1821–30	0·1	...	0·3	0·9	1·3	1·4	2·4	**2·6**	1·4	0·4	0·3	0·4	11·5
1831–40	0·1	...	0·1	0·7	1·6	**2·8**	2·4	2·2	0·7	0·5	0·3	0·4	11·8
1841–50	0·2	0·1	...	0·7	1·2	2·0	**2·6**	2·5	0·9	0·1	0·2	...	10·5
1851–60	0·2	...	...	1·2	1·4	2·3	**3·2**	1·9	1·3	0·3	0·1	...	11·9
1861–70	...	...	0·3	0·5	1·5	1·8	**2·2**	1·5	1·2	0·4	0·2	...	9·6
1871–80	...	...	0·1	1·6	1·8	2·7	**4·5**	2·6	1·3	0·8	0·2	0·1	15·7
1881–90	...	0·1	0·1	1·1	1·9	2·2	**3·8**	2·3	1·1	0·1	0·1	0·2	13·0

The maximum in each decade is shown by the figures in heavy type.

Lightning without Thunder.

This meteor does not seem to have been systematically recorded till the commencement of Belville's Greenwich observations, so I have restricted the examination of the data to the 86 years, 1811-1896. During this time 619 cases of lightning only were recorded, an average of 7·2 per annum. The maximum, of 21 cases, took place in 1884. The annual period differs from that of thunderstorms in having its maximum in August, while the values for September and October, as will be seen from the following figures, are proportionately much higher than those for thunderstorms:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
Total . . .	25	12	12	32	57	59	73	104	88	85	38	34
Per cent . .	4·0	2·0	2·0	5·2	9·2	9·5	11·8	16·8	14·2	13·7	6·1	5·5

Reference to the curves will show that maxima of lightning usually correspond with minima of thunderstorms, and *vice versâ*. In this connection the two curves for the years 1830, 1835, 1859, 1871, 1878, and 1890 should be compared.

Thunderstorms reach a maximum in the three hours ending 5 p.m., and are at a minimum in the early morning. The daily period is much the same both for summer and winter occurrences of this phenomenon. Lightning without thunder is essentially a nocturnal phenomenon, reaching a maximum at 10 p.m. The minimum during the day is partially due to many cases of lightning not being visible owing to the daylight. It is to be noted that only in a comparatively small number of cases was the hour reported at which the phenomenon occurred.

TABLE II.—Days of Lightning without Thunder. Decennial Means.

Decades.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1821-30	0·1	0·1	...	0·5	0·9	0·5	0·7	0·7	0·7	0·8	0·8	0·7	6·5
1831-40	0·3	0·3	0·1	0·1	0·6	1·0	0·9	1·3	0·5	1·1	1·0	1·0	8·2
1841-50	0·2	0·1	0·3	0·7	0·6	0·6	0·9	0·6	1·5	0·8	0·3	0·1	6·7
1851-60	0·5	...	...	0·3	0·6	0·6	0·8	1·3	1·2	0·8	...	0·5	6·6
1861-70	0·3	0·4	0·1	0·1	1·2	0·6	1·1	1·7	1·7	1·4	0·8	0·4	9·8
1871-80	0·7	0·1	0·3	0·5	0·7	0·8	0·9	2·2	1·5	1·6	0·4	...	9·7
1881-90	0·4	0·1	...	0·3	0·8	1·2	1·2	1·5	0·9	1·0	0·4	0·3	8·1

Mist and Fog.

The preparation of this table has been a matter of much difficulty owing to erroneous entries of haze. Every effort has been made to detect and eliminate these, but it is obvious that a number must remain. Cases of dense or thick fog are included in Table III., but will also be found by themselves in Table IV. The total number of fogs was 4076, an average of 24·4 per annum. They increase rapidly during September, but the maximum is not clearly defined, the values for October, November, and December being practically the same. The minimum is reached in June. The following are the values:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Total . . .	509	330	270	150	84	77	78	164	499	642	640	633
Per cent . .	12·5	8·1	6·6	3·7	2·1	1·9	1·9	4·0	12·3	15·7	15·7	15·5

Statistics of "dense" or "thick" fogs are available for the years 1763-1782 and 1811-1896. The number observed in all was 611, an average of 5·8 per annum. They are most frequent in November, which has 125 cases, the minimum being reached in July with only 4 dense fogs during the 106 years under review. Their distribution throughout the year is shown in the following figures:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Total . . .	84	59	35	13	11	6	4	7	65	92	125	110
Per cent . .	13·5	9·5	5·7	2·1	1·8	1·0	0·6	2·7	10·5	14·8	20·1	17·7

The foggiest year was 1873 with 74 fogs, and the greatest number of dense fogs was 19 in 1891. The foggiest month was December 1879, with 17 foggy days. December 1890 had the maximum number of dense fogs, viz. 8.

An examination of Fig. 2 exhibits in a clear manner the great increase of fog during recent years, the numbers since 1867 being persistently high. Taking decadal means we get the following mean annual values, the station being Greenwich:—

Decade.	Fogs.	Dense Fogs.	Decade.	Fogs.	Dense Fogs.
1811-20	18·7	2·4	1851-60	33·0	7·6
1821-30	19·6	2·5	1861-70	38·8	8·1
1831-40	26·3	5·2	1871-80	48·8	9·0
1841-50	22·1	3·9	1881-90	54·8	9·3

The increase in the decennial means since 1841 has thus been steady and uninterrupted. Reference to the above figures will show that while the mean annual number of fogs in the decennium ending with 1850 was 22 per annum, the number in the decennium ending with 1890 had risen to 55 per annum, an increase of 150 per cent. The corresponding values for dense fogs being 4 days and 9 days. It is impossible to calculate what this increase in fog represents, in injury to health and interruption to traffic. The falling off in the values since 1890 is probably due to the comparative absence of the atmospheric concurrents that are necessary for the production of fog.

In the 33 years ending May 1745 only 56 dense fogs were experienced, being an average of less than 2 per annum. They were distributed throughout the year as follows:—

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
7	6	1	0	0	0	0	0	2	5	16	19

It must be remembered that these observations were taken at Richmond, and are therefore not strictly comparable with those taken in London.

The seasonal distribution of dense fog has not materially changed during at least the last 180 years.

TABLE III.—Days of Fog. Decennial Means.

Decades.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1721–30	1·9	2·1	0·9	*0·2*	*0·2*	0·3	0·3	1·1	2·8	**4·4**	3·3	1·6	19·1
1731–40	1·2	*0·2*	*0·2*	1·1	0·3	*0·2*	0·7	0·8	2·8	**3·4**	3·0	1·6	15·5
1771–80	2·6	2·9	2·1	0·8	1·5	*0·2*	0·9	2·3	4·0	3·9	3·4	**6·6**	31·2
1781–90	**4·1**	1·0	0·5	0·3	0·3	0·2	*0·1*	0·7	2·6	2·8	2·9	1·7	17·2
1791–00	2·9	1·2	0·9	0·4	0·1	0·4	*0·0*	1·0	2·4	1·3	2·5	**4·2**	17·3
1801–10	3·2	0·4	0·8	0·3	0·3	*0·1*	0·6	0·6	2·5	**4·8**	2·9	3·7	20·2
1811–20	2·5	1·8	1·0	1·2	0·8	0·5	*0·1*	0·3	2·4	1·9	**3·1**	**3·1**	18·7
1821–30	**3·9**	2·6	0·7	0·5	0·3	0·6	*0·0*	1·0	0·9	2·5	3·6	3·0	19·6
1831–40	3·3	2·6	1·9	1·0	*0·2*	0·5	0·4	1·1	3·0	**4·4**	3·5	**4·4**	26·3
1841–50	2·3	1·5	1·9	1·9	1·1	0·6	*0·5*	0·8	3·1	2·3	3·0	**3·1**	22·1
1851–60	3·8	2·1	2·8	1·0	0·5	*0·4*	*0·4*	0·9	4·7	5·2	**7·3**	3·9	33·0
1861–70	4·4	2·4	2·4	1·2	*0·3*	0·6	0·5	1·1	4·0	7·3	**8·6**	6·0	38·8
1871–80	4·3	5·0	4·7	1·7	*0·5*	1·1	0·8	1·5	4·8	**8·8**	7·3	8·3	48·8
1881–90	7·1	4·7	4·5	2·5	1·8	*1·5*	1·7	2·4	6·5	**8·2**	5·7	**8·2**	54·8

TABLE IV.—Days of Dense Fog. Decennial Means.

Decades.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1771–80	0·4	**0·8**	...	0·1	0·3	...	...	...	0·1	0·1	0·6	0·6	3·0
1811–20	0·6	0·4	...	...	...	...	...	...	...	0·1	0·5	**0·8**	2·4
1821–30	0·2	0·2	...	...	...	0·1	...	0·2	0·1	0·2	0·7	**0·8**	2·5
1831–40	0·8	0·6	0·2	0·3	0·1	...	0·1	0·3	0·5	0·4	**1·1**	0·8	5·2
1841–50	...	0·3	0·5	0·4	0·3	0·1	0·1	0·1	0·8	0·2	0·5	**0·6**	3·9
1851–60	1·0	0·5	0·3	0·1	0·1	0·1	0·1	0·4	0·8	1·4	**2·2**	0·6	7·6
1861–70	1·4	0·4	0·3	0·2	...	...	...	...	0·6	1·9	**2·5**	0·8	8·1
1871–80	0·9	1·2	0·7	...	0·1	0·1	...	0·2	1·2	**2·1**	1·4	1·1	9·0
1881–90	1·7	0·8	0·7	...	...	0·1	0·1	0·3	1·1	1·2	1·2	**2·1**	9·3

Snow.

The total number of days with snow was 2267, an average of 13·6 per annum. Their distribution throughout the months is shown in the following figures:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Total . . .	597	477	497	177	22	0	0	0	2	18	108	369
Per cent . .	26·3	21·0	21·9	7·8	1·0	0·0	0·0	0·0	0·1	0·8	4·8	16·3

The snowiest winter was that of 1887-88 with 43 days, while in the winter of 1862-63 there is not a single instance of a snowfall.[1] The greatest number of cases was 17 in January 1814, closely followed by February 1888 with 15 days on which snow fell.

Table VI. shows the snowfalls grouped by winters with date of first and last fall. The mean date of first snowfall is November 9, the earliest date being September 24 in 1811, and the latest April 10 in 1834. The mean date of last snow is March 30, the extreme dates being January 6, 1894, and May 27, 1821. The following figures show the number of times the first and last fall of snow occurred in 164 winters:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
First Snow .	28	6	2	1	0	0	0	0	2	14	55	56
Last Snow .	6	11	65	66	16	0	0	0	0	0	0	0

In Table VII. will be found decennial means of the extreme dates during which snow was observed.

Looking at the values delineated on Fig. 3, it will be observed that there has been on the whole a steady increase in the mean annual number of days with snow. There is some appearance of a cycle, but as the recurring periods of maxima and minima are of unequal length, we cannot dogmatise on the matter. The small number of days with snow recorded by Smith is remarkable, especially when we consider the popular opinion regarding "old-fashioned" winters. There can be no doubt that nearly all the winters from about 1717 to 1737 were mild with little snow. This is apparent on reading the descriptive weather notes extracted from the register, and recently published in *Symons's Monthly Meteorological Magazine*, vol. xxxi. p. 161.

TABLE V.—DAYS OF SNOW. DECENNIAL MEANS.

Decades.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1721–30	**1·8**	0·9	1·5	0·1	...	...	...	...	...	...	0·3	1·7	6·3
1731–40	**1·8**	1·7	1·7	0·3	0·2	...	...	...	...	...	0·5	1·0	7·2
1771–80	**4·7**	3·7	2·3	0·8	...	...	...	...	...	...	2·0	1·7	15·2
1781–90	2·2	3·0	**4·1**	1·6	0·1	...	...	...	...	0·3	0·3	2·4	14·0
1791–00	1·8	**2·6**	1·5	0·8	...	...	...	...	...	...	0·4	1·6	8·7
1801–10	**3·5**	3·2	3·0	2·3	...	...	...	...	...	0·1	0·7	2·9	15·7
1811–20	**5·7**	1·9	3·1	0·7	...	...	...	...	0·1	0·2	0·5	3·2	15·4
1821–30	**4·5**	2·3	1·7	0·5	0·1	...	...	...	...	0·2	0·4	1·9	11·6
1831–40	**3·9**	2·5	2·9	2·5	0·3	...	...	...	...	0·3	0·3	1·5	14·2
1841–50	**5·4**	4·0	3·1	1·3	0·1	...	...	...	...	0·1	0·6	2·2	16·8
1851–60	2·9	**4·1**	3·5	1·2	0·3	...	...	...	...	0·1	0·6	2·9	15·6
1861–70	4·0	3·8	**5·2**	0·1	0·1	...	...	...	...	0·2	0·8	3·0	17·2
1871–80	4·1	3·4	**4·3**	1·1	0·2	...	...	...	...	0·2	1·8	3·9	19·0
1881–90	3·9	4·4	**5·4**	1·4	0·2	...	...	...	0·1	0·1	0·9	3·4	19·8

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[1] I was so surprised at the occurrence of an absolutely snowless winter that I wrote Mr. Symons asking whether he could corroborate this fact from his own observations. He replied, "There is no record of snow, and I have further referred to Mr. Prince's *Climate of Uckfield*. I find no notice there, nor can I find any in FitzRoy's *Daily Weather Reports*." Mr. Scott has kindly favoured me with the following list of snowfalls in the British Islands during the winter of 1862-63, the entries being extracted from FitzRoy's *Weather Reports*. During the winter of 1862-63 snow fell at the following places:—

Nov. 10. Leith, Galway, Valencia.
, 11. Nairn, Leith, Berwick, Galway, Valencia, Queenstown, Scarborough, Shields.
„ 26. Aberdeen, Leith, Berwick.
„ 27. Nairn, Leith, Berwick.
Dec. 27. Nairn, Aberdeen.
Jan. 5. Nairn.
Jan. 13. Valencia.
„ 20. Aberdeen, Leith, Ardrossan, and Shields.
„ 21. Ardrossan.
Mar. 9. Aberdeen.
„ 10. Valencia.
„ 12. Aberdeen.
„ 18. Ardrossan.

TABLE VI.—Days of Snow, Grouped by Winters, with Date of First and Last Fall.

Winter.	Days	First Snow.	Last Snow.
1713–14	6	Dec. 4	April 15
1714–15	9	Dec. 22	April 4
1715–16	17	Nov. 4	Feb. 4
1716–17	10	Dec. 10	Mar. 29
1717–18	7	Jan. 3	Feb. 8
1718–19	6	Dec. 29	Mar. 27
1719–20	13	Nov. 13	Mar. 27
1720–21	6	Jan. 26	April 5
1721–22	4	Nov. 28	Mar. 27
1722–23	6	Dec. 4	Feb. 10
1723–24	3	Feb. 24	Mar. 16
1724–25	4	Nov. 24	Mar. 30
1725–26	9	Jan. 13	Mar. 6
1726–27	9	Dec. 15	April 1
1727–28	5	Dec. 27	Mar. 1
1728–29	13	Dec. 1	Mar. 22
1729–30	4	Feb. 6	Mar. 10
1730–31	10	Dec. 7	Mar. 7
1731–32	5	Jan. 5	Mar. 21
1732–33	2	Mar. 31	April 1
1733–34	1	Jan. 16	Jan. 16
1734–35	3	Dec. 14	Mar. 5
1735–36	10	Dec. 17	Mar. 14
1736–37	7	Dec. 17	Feb. 4
1737–38	5	Dec. 31	Mar. 13
1738–39	12	Jan. 2	April 20
1739–40	9	Nov. 17	May 16
1740–41	17	Nov. 3	April 30
1741–42	8	Jan. 9	April 3
1742–43	12	Dec. 14	April 19
1743–44	11	Dec. 28	April 13
1744–45	10	Nov. 30	Mar. 15
1763–64	8	Nov. 20	Mar. 6
1764–65	10	Feb. 25	Mar. 1
1765–66	12	Nov. 5	Mar. 30
1766–67	12	Jan. 3	May 5
1767–68	10	Dec. 26	April 7
1768–69	8	Nov. 23	April 4
1769–70	22	Dec. 28	May 4
1770–71	24	Jan. 4	April 17
1771–72	14	Jan. 7	April 18
1772–73	5	Jan. 16	Feb. 10
1773–74	7	Nov. 25	Mar. 2
1774–75	19	Nov. 11	Mar. 28
1775–76	15	Nov. 15	Mar. 3
1776–77	18	Dec. 27	Mar. 28
1777–78	23	Dec. 6	April 20
1778–79	7	Jan. 9	Jan. 25
1779–80	15	Nov. 14	April 18
1780–81	9	Nov. 5	Mar. 28
1781–82	15	Jan. 21	April 27
1782–83	13	Nov. 25	May 7
1783–84	22	Dec. 25	April 11
1784–85	28	Oct. 25	April 2
1785–86	18	Oct. 26	April 9
1786–87	5	Dec. 23	Jan. 28
1787–88	6	Dec. 22	April 22
1788–89	23	Nov. 27	April 4
1789–90	3	Dec. 16	April 15
1790–91	7	Nov. 30	Feb. 26
1791–92	7	Dec. 9	Feb. 19
1792–93	11	Dec. 27	April 24
1793–94	2	Jan. 25	Jan. 27
1794–95	19	Dec. 25	Mar. 17
1795–96	3	Feb. 29	Mar. 27
1796–97	7	Nov. 16	April 3
1797–98	4	Nov. 19	Mar. 30
1798–99	19	Nov. 22	Mar. 14
1799–1800	10	Dec. 18	Mar. 10
1800–01	8	Dec. 31	April 12
1801–02	14	Nov. 27	Mar. 29
1802–03	14	Jan. 18	Mar. 12
1803–04	11	Dec. 6	April 20
1804–05	18	Dec. 18	April 29
1805–06	20	Dec. 10	April 15
1806–07	18	Jan. 14	April 18
1807–08	17	Nov. 19	April 21
1808–09	25	Nov. 19	April 21
1809–10	11	Nov. 18	April 11
1810–11	9	Oct. 30	Feb. 13
1811–12	20	Sept. 24	April 24
1812–13	15	Dec. 11	April 22
1813–14	31	Nov. 17	Mar. 16
1814–15	13	Dec. 25	Mar. 9
1815–16	15	Nov. 16	April 14
1816–17	10	Nov. 10	April 10
1817–18	13	Dec. 3	Mar. 12
1818–19	5	Feb. 2	Mar. 1
1819–20	22	Oct. 21	Mar. 7
1820–21	6	Nov. 17	May 27
1821–22	2	Jan. 5	April 10
1822–23	13	Dec. 31	Mar. 20
1823–24	8	Dec. 19	April 11
1824–25	7	Jan. 19	Mar. 5
1825–26	7	Oct. 20	Mar. 26
1826–27	19	Nov. 26	April 24
1827–28	10	Nov. 22	Mar. 6
1828–29	7	Jan. 6	April 2
1829–30	33	Oct. 7	April 1
1830–31	15	Dec. 16	Mar. 24
1831–32	4	Nov. 16	Mar. 24
1832–33	11	Jan. 31	April 15
1833–34	2	April 10	April 12
1834–35	9	Nov. 21	April 26
1835–36	16	Dec. 10	April 29
1836–37	29	Oct. 29	May 10
1837–38	23	Dec. 6	April 29

TABLE VI.—DAYS OF SNOW GROUPED BY WINTERS, WITH DATE OF FIRST AND LAST FALL.—*Continued.*

Winter.	Days	First Snow.	Last Snow.	Winter.	Days	First Snow.	Last Snow.
1838–39	25	Oct. 13	May 15	1867–68	18	Dec. 2	Mar. 25
1839–40	9	Jan. 6	Mar. 26	1868–69	12	Nov. 8	Mar. 28
				1869–70	33	Oct. 27	Mar. 29
1840–41	22	Nov. 18	Feb. 9				
1841–42	20	Nov. 14	Mar. 23	1870–71	34	Nov. 10	Mar. 16
1842–43	20	Jan. 10	May 6	1871–72	15	Nov. 17	Mar. 26
1843–44	15	Jan. 1	Mar. 12	1872–73	15	Nov. 13	April 25
1844–45	25	Dec. 9	Mar. 18	1873–74	6	Jan. 5	Mar. 12
1845–46	6	Dec. 21	Mar. 20	1874–75	17	Dec. 2	Mar. 2
1846–47	31	Dec. 10	April 16	1875–76	31	Nov. 25	April 14
1847–48	8	Dec. 28	April 9	1876–77	13	Nov. 8	April 17
1848–49	10	Oct. 18	April 19	1877–78	12	Dec. 26	April 1
1849–50	16	Nov. 26	Mar. 27	1878–79	42	Oct. 30	May 7
				1879–80	14	Nov. 20	Jan. 22
1850–51	8	Dec. 19	May 4				
1851–52	2	Nov. 16	Feb. 10	1880–81	26	Oct. 20	April 21
1852–53	26	Feb. 5	May 7	1881–82	4	Nov. 1	Mar. 22
1853–54	17	Nov. 24	April 24	1882–83	19	Nov. 16	May 11
1854–55	28	Nov. 27	Mar. 29	1883–84	8	Dec. 6	May 5
1855–56	10	Dec. 3	Feb. 21	1884–85	9	Nov. 30	Mar. 22
1856–57	20	Nov. 26	April 13	1885–86	30	Sept. 25	April 29
1857–58	15	Nov. 26	April 9	1886–87	20	Dec. 2	April 14
1858–59	2	Mar. 30	April 16	1887–88	43	Oct. 12	April 8
1859–60	24	Oct. 24	April 24	1888–89	19	Jan. 7	Mar. 21
				1889–90	14	Nov. 27	April 8
1860–61	12	Dec. 17	April 27				
1861–62	6	Nov. 2	Mar. 21	1890–91	29	Nov. 26	May 16
1862–63	0	...	...	1891–92	25	Jan. 5	April 17
1863–64	19	Dec. 28	Mar. 30	1892–93	16	Dec. 4	Mar. 17
1864–65	29	Dec. 17	Mar. 29	1893–94	7	Nov. 19	Jan. 6
1865–66	11	Jan. 1	Mar. 22	1894–95	26	Dec. 30	Mar. 4
1866–67	21	Jan. 1	May 22	1895–96	5	Dec. 7	Mar. 3

TABLE VII.—MEAN DATE OF FIRST AND LAST SNOW BY DECADES.

Decades.	First Snow.	Last Snow.
1721–30	December 29	March 16
1731–40	,, 31	,, 15
1771–80	,, 14	,, 21
1781–90	,, 3	April 6
1791–1800	,, 19	March 14
1801–10	,, 12	April 13
1811–20	November 22	March 22
1821–30	December 5	April 5
1831–40	,, 16	,, 18
1841–50	,, 7	March 29
1851–60	,, 14	April 7
1861–70	,, 5	,, 5
1871–80	November 25	March 27
1881–90	,, 14	April 13

Hail.

Hail is essentially a spring phenomenon, reaching a maximum in March and April. The minimum is in July and August. It is probable that most of the cases in summer are falls of true hail accompanying thunderstorms, whereas in spring in nearly every case the substance precipitated is "graupel" or soft hail. The total number of falls observed was 988, equal to an average of 5·9 per annum. Its distribution throughout the year is as follows:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Total . . .	54	112	227	229	135	50	25	20	31	29	31	45
Per cent . .	5·5	11·3	23·0	23·1	13·7	5·1	2·6	2·0	3·1	2·9	3·1	4·6

Little can be said about the secular variation. The most noticeable feature apparent from an inspection of Fig. 4 is the falling off in the values since 1840. May not this be due to the better discrimination between cases of hail and snow on the part of the Greenwich observers? If this be so, the increase in the number of snowy days is accounted for.

TABLE VIII.—DAYS OF HAIL. DECENNIAL MEANS.

Decades.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1721–30	0·3	0·5	1·0	1·0	0·3	0·2	0·1	...	...	0·2	...	0·2	3·8
1731–40	0·1	0·6	2·9	0·6	0·8	0·2	0·1	0·1	0·4	0·1	...	0·2	6·1
1771–80	0·6	1·2	1·1	2·1	0·7	0·6	0·1	...	0·2	0·1	0·5	0·3	7·5
1781–90	0·3	0·5	1·1	0·8	0·3	0·3	0·2	0·1	...	0·3	0·2	0·4	4·5
1791–00	0·1	0·9	1·1	0·7	0·7	0·2	...	0·1	0·1	0·3	0·3	0·1	4·6
1801–10	0·3	1·1	2·3	2·6	0·9	0·2	0·2	0·2	0·1	0·2	0·4	0·2	8·7
1811–20	0·1	0·7	0·8	0·3	0·3	0·3	0·2	...	0·1	0·1	...	0·2	3·1
1821–30	0·1	0·2	1·2	0·5	0·4	0·4	...	0·2	...	...	0·1	0·4	3·5
1831–40	0·5	1·1	0·9	2·0	1·1	0·5	0·1	0·5	0·2	0·2	0·5	0·4	8·0
1841–50	0·9	0·9	1·6	2·6	1·6	0·5	0·3	0·1	0·2	0·1	0·3	0·6	9·7
1851–60	0·4	0·5	1·6	2·1	2·2	0·7	0·1	0·3	...	0·1	0·1	0·2	8·3
1861–70	0·3	0·7	1·9	1·5	0·7	0·2	0·1	0·1	0·3	0·2	...	0·2	6·2
1871–80	0·8	0·2	0·8	1·8	0·5	0·2	0·2	...	0·4	0·4	0·3	0·3	5·9
1881–90	0·2	0·5	0·7	0·9	0·6	0·1	0·4	0·1	0·2	...	0·2	0·2	4·1

Gales and High Winds.

It has not been considered advisable to reproduce the curve showing the smoothed annual number of gales and high winds, there being no definite standard to go by, as may be judged from some of the terms used, which include such entries as "gale," "strong gale," "tempestuous," "stormy," "windy," "high wind," etc. Decennial means have, however, been given, as they afford some indication of the relative strength of the wind. The number of stormy days in the 167 years was 3669, distributed throughout the year as follows:—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Total . . .	471	391	458	271	216	160	198	187	242	294	325	456
Per cent . .	12·8	10·6	12·5	7·4	5·9	4·4	5·4	5·1	6·6	8·0	8·9	12·4

The mean annual number is 22.

TABLE IX.—DAYS OF GALES AND HIGH WINDS. DECENNIAL MEANS.

Decades.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1721–30	4·0	3·0	**4·7**	4·0	3·0	3·2	3·4	2·9	*2·3*	3·0	2·9	3·7	40·1
1731–40	5·4	4·9	**5·8**	3·4	3·1	*1·6*	2·3	1·7	5·0	2·4	2·1	5·3	43·0
1771–80	**2·6**	2·1	1·4	0·6	0·5	*0·4*	0·9	1·4	1·4	1·9	2·1	1·2	16·5
1781–90	**2·1**	1·8	1·3	1·4	0·8	*0·5*	0·9	*0·5*	1·9	1·1	1·0	1·2	14·5
1791-1800	1·2	**1·5**	0·8	0·5	0·6	0·3	*0·3*	0·8	0·6	1·0	0·9	1·0	9·5
1801–10	**3·2**	1·7	2·6	1·2	*0·5*	*0·5*	*0·5*	0·9	0·8	0·9	2·4	3·0	18·2
1811–20	3·5	3·9	4·2	2·0	1·8	1·1	*0·5*	1·5	2·1	2·4	1·7	**4·5**	29·2
1821–30	2·3	1·3	**4·3**	2·1	1·1	*0·3*	1·2	1·3	1·6	1·9	3·7	3·4	24·5
1831–40	3·9	**4·1**	3·9	1·3	2·0	3·0	3·5	2·5	*1·2*	3·1	2·7	**4·1**	35·3
1841–50	4·1	3·2	**4·2**	2·0	1·9	2·2	2·2	1·1	*0·8*	2·6	2·2	2·1	28·6
1851–60	2·2	2·1	1·0	0·9	0·7	0·8	0·9	*0·3*	*0·3*	1·5	1·0	**2·7**	14·4
1861–70	2·9	2·0	1·2	0·7	0·4	*0·1*	0·2	0·4	1·6	1·4	2·3	**3·4**	16·6
1871–80	2·0	0·3	2·3	0·8	0·7	0·5	*0·1*	0·3	0·3	1·1	**2·4**	1·2	12·0
1881–90	**2·5**	1·4	1·4	1·1	0·9	*0·2*	0·6	0·8	0·7	0·7	1·4	1·0	12·7

DISCUSSION.

The President (Mr. E. MAWLEY) said that the discussion of such a large number of observations, as in this paper, must necessarily involve a large amount of time and labour, and he thought Mr. Mossman was to be congratulated on the result; though for his own part he rather doubted if the real scientific value of the paper was commensurate with the energy expended in its compilation. If the various phenomena continued increasing in the same proportion as given in the paper, the weather of London would be something to be feared in the future. He was sure the "personal equation" difficulty, which Mr. Mossman had mentioned, was a very serious one to contend with. An interesting point in the paper was the unearthing of a snowless winter for London, viz. that of 1862-3.

Mr. R. H. SCOTT remarked that, according to Mr. Mossman, in the winter of 1833-4 the first and only snow fell on April 11, 1834. It ought also to be put on record, as an instance in direct contrast to this, that snow had been observed in the "dog days," viz. July 11, 1888, as near to the metropolis as Norwood, and it was on record that market carts from that district came into London with snow on their covers. On that occasion snow fell even in the Isle of Wight. The Registrar-General's Return for that week gave a notice of snow at Oxford, but it did not appear that any had been observed at Greenwich.

Mr. W. ELLIS said that Mr. Mossman must have expended a large amount of time and labour on the paper, for which he deserved every credit. Still, the results would appear to be of unequal merit. Those which show the seasonal change of the different phenomena he (Mr. Ellis) considered to be much more valuable than those for decennial periods, so far as these are supposed to be useful for the comparison together of the values in different decennial periods. For we cannot be satisfied that in the different periods the variation of value frequently to be seen, in individual months, between the early and late epochs, is not in a great degree due to personality of observers. Consequently he could not, without better evidence, believe that thunderstorms had increased in 170 years, a very small period when climatic changes are in question, to the extent shown in Table I., or that fogs had increased as shown in Table III., or that snow had become more frequent as shown in Table V. The seasonal results, depending on combination of the whole of the observations, are more trustworthy, since the personality in observing which, according to the decennial means, would appear to exist, is relatively small as compared with the larger seasonal change in each case shown—so that the seasonal results may be taken as giving fair approximations to the truth, the effect of personality being here simply to make each annual curve a little bolder or a little flatter than it would otherwise be, whilst still preserving its main features. The results for gales of wind confirm what has been previously found, that there is no abnormal increase at the equinoxes. As regards the winter of 1862-3, said to be without snow, there were at Greenwich during the months of December, January, and February, of this winter, only 12 days on which the temperature fell below the freezing-point, and only one day on which the maximum temperature fell below 40°. The mean temperatures of the same three months were respectively $4^\circ{\cdot}0$, $3^\circ{\cdot}7$, and $2^\circ{\cdot}7$ above the average, which so far corroborates the fact stated. It is said that the eleven-year period comes out fairly well in the maxima and minima of thunderstorms. When the eleven-year period is mentioned it is presumed that the reference is to the sunspot cycle. But of the 9 cases of maxima of thunderstorms, 3 occur with sunspot maximum, 4 with sunspot minimum, and 2 half-way between sunspot maximum and minimum. Of the 8 cases of minimum of thunderstorms, 1 occurs with sunspot maximum, 1 with sunspot minimum, 4 half-way between sunspot maximum and minimum, and 2 half-way between sunspot minimum and maximum. Thus there is no definite relation with the sunspot cycle.

Mr. F. J. Brodie was inclined to doubt whether the results yielded by the discussion were commensurate with the labour that must have been expended in dealing with so vast a mass of material. For his own part he expressed some dislike for any series of observations made up, as in this case, by piecing together the records kept at all kinds of different places, some of them quite outside the metropolitan area. The long Greenwich record might be accepted as of great value, but with regard to the observations made in earlier years too little was known as to the conditions under which they were set down, and the rules kept by the various observers. He would have been glad to know whether, in the statistics relating to thunderstorms, the occurrence of thunder only was included; the figures seemed to show that such was the case. The diminution in the prevalence of fog within recent years was amply confirmed by the observations of the Meteorological Office, and was apparently due to causes other than atmospherical, the conditions in some winters, such as that of 1895-6, being often highly favourable for its formation. He was inclined to think that the boundaries the author had laid down for the winter seasons (given in the table of snows) were far too wide. Neither September nor April could fairly be regarded as a winter month. Confining the winter within its proper limits, it would be seen that the season of 1833-4 was, like that of 1862-3, quite snowless. With regard to snow in summer, he might state that in addition to the slight fall on July 11, 1888 (referred to by Mr. Scott), there were a few flakes on June 3, 1887. The London observations made by the Meteorological Office showed that in the course of the past twenty-five years the only month without any record of snow was August.

Mr. G. J. Symons had always considered the position of Greenwich Observatory one of the worst possible for making astronomical observations, being as it was often enveloped in fog and smoke. With regard to Mr. Mossman's figures of hail, he thought that they had been confused by the inclusion by some observers and the exclusion by others of "graupel" or soft hail.

Mr. H. Southall asked what value attached to the distinction of the difference between lightning with and without thunder.

Mr. G. J. Symons said he thought that lightning was quite possible without thunder. To show the distance at which the lightning of a storm was visible, it was observed one evening in 1857 at Nottingham, the direction being south, and was traced to the coast, all the intermediate observations reporting it as southward. In the Channel a severe thunderstorm was going on, so that there seemed no other explanation of the observation of lightning at Nottingham than that it was the reflection of that storm, yet it would be incorrect to say a thunderstorm occurred at Nottingham. If, on the other hand, thunder was heard, it was safe to assume that the centre of the storm was within reasonable distance, say 10 or 15 miles.

Mr. W. **Marriott** said that Mr. Mossman had recently discussed observations extending over a period of 130 years for Edinburgh, and he had now turned his attention to London, and had treated the observations in a similar manner for 167 years. He thought that if the thunderstorm curve were carefully studied, and its irregularities daily considered, the increase of this phenomenon would scarcely be so apparent. The results given in his (Mr. Marriott's) paper, "Distribution of Thunderstorms over England and Wales, 1871-1887," agreed very well with those for the same period given in the present paper. He thought observations of thunder should always be treated as thunderstorms, as the audibility of thunder rarely exceeded 10 miles, and it was probable that the storm was within that radius; in addition to which (should the occurrence take place in the day-time) lightning might not always be seen. He had on a former occasion brought before the Society an instance of lightning having been seen at a distance of more than 100 miles from the thunderstorm (vol. xiv. p. 296). Lightning observed in London in the evening was often the reflection from thunderstorms travelling up or down the English Channel.

Mr. B. **Latham** said that increase of fogs as shown by Table III. was corroborated by Table IX., which was a record of high winds and gales; for it would be seen by comparing the tables, that while fogs had been increasing, high winds and gales had been diminishing in a corresponding ratio, which corroborated the correctness of the table as to the probable increase in the amount of fogs, as fogs were non-existent at the time when the wind was subject to brisk movement.

Mr. R. C. **Mossman**, in a note to the Secretary, in reply, said he fully concurred with the opinions expressed regarding the doubtful character of the results shown by the older registers, but thought that the long Greenwich record might be accepted as having considerable scientific value. With regard to thunderstorms, cases of lightning without thunder had been included as such. The increase in thunderstorms seems to be a real one, as is shown by the Edinburgh values for the last ten decades, during which time a steady rise in thunderstorm frequency is exhibited.

HAILSTORM IN THE SOUTH-WEST OF LONDON, April 27, 1897.

By CHARLES HARDING, F.R.Met.Soc.

[Read June 16, 1897.]

A hailstorm of such unusual severity occurred in the south-west suburbs of London on the evening of Tuesday, April 27, that a few details with respect to it may be of interest to the Society.

The conditions on the day preceding the storm were decidedly favourable to the development of thunderstorms over our islands, and the type of weather had, in comparison with that of several previous days, undergone considerable change. The morning report issued by the Meteorological Office showed that lightning had already been reported at Jersey and Prawle Point, while at the latter place very heavy rain had fallen. A heavy thunderstorm had occurred in France, and in Paris the rainfall amounted to about an inch. The morning was very gloomy in the metropolis, and the air was warm, while the Easterly wind which had been so persistent for days had completely subsided. In the southern suburbs of London, and at Brixton and Streatham especially, the fog and gloom continued throughout the day, but in Westminster, and in the more central parts of London, the air cleared greatly in the afternoon, and bright sunshine was experienced for a time. About 5 p.m. massive clouds were seen to be forming in the south and south-west, and distant thunder was first heard at Tulse Hill, where my own observations were made, shortly after 5.30 p.m. The lightning became very vivid shortly after 6 p.m., and many of the flashes were followed, in some cases almost instantaneously, by deafening peals of thunder. Up till 6.30 p.m. no rain or hail whatever had fallen, but about this time very large rain-drops began to fall, each leaving a spot on the ground as large as half-a-crown. A minute or so later hail began to fall very thickly and heavily; this continued without any abatement for fully ten minutes, until 6.40 p.m., during which time the thunderstorm was at its height. The hail still continued to fall till about 6.50 p.m., after which there was a little rain, but certainly not more than one or two hundredths of an inch. The ground was completely covered with hail, many of the stones being of the size of small marbles, but not so round, and by far the bulk of the stones resembled in shape and size a small acid drop, the stones being circular but flattened, and the edges quite flat and sharp. The underneath side of the stone was less white and more icy in appearance than the upper side, and the upper side was decidedly the flatter of the two. When broken the stones were of an icy-bluish appearance, and not white. As the storm was slackening in its violence I gathered several handfuls of stones and threw them from me, throwing 4 or 5 in fewer seconds. In less than twenty minutes from 6.30 p.m. I measured 0·85 in. of hail and rain, but by far the largest bulk was hail. During the day the temperature in London rose to 67°, which was the highest reading this year. At 6.30 p.m., immediately prior to the storm, the thermometer in a Stevenson screen at Tulse Hill read 60°, and at 6.50 p.m., as the storm was passing away, the same thermometer stood at 50°, having fallen 10°.

After the storm I had occasion to traverse Brixton Hill, where there was ample evidence of the state of flood which had existed, and from reports received from friends in the neighbourhood I knew that many of the houses had several inches of water in their basements. Later in the evening, by about 9 p.m., the sky had become partially cleared and the stars were visible. Later, at 10 and 11 p.m., there was a dense fog in the southern suburbs, and it was for a time quite impossible to see objects 12 yards distant. My total rainfall at Tulse Hill, measured at 9 a.m. on April 28, was 0·97 in., which is in remarkable agreement with that measured at the Lambeth Waterworks at the foot of Brixton Hill, the two gauges being about half a mile apart.

I have gathered and preserved numerous specimens of leaves, etc., showing the damage sustained by vegetation. Certainly on some of my fruit trees not a single whole leaf was remaining after the storm; and the ground after the hail had disappeared was completely strewn with leaves and blossoms. Large well-grown Aucubas had their leaves completely pierced, the hailstones passing through the leaves, and in very many cases leaving the piece of leaf hanging on the other side by a mere fibre. From inquiries in my own immediate neighbourhood there does not appear to have been much damage done to glass by breakage—but gardeners speak of young plants being completely stripped of foliage.

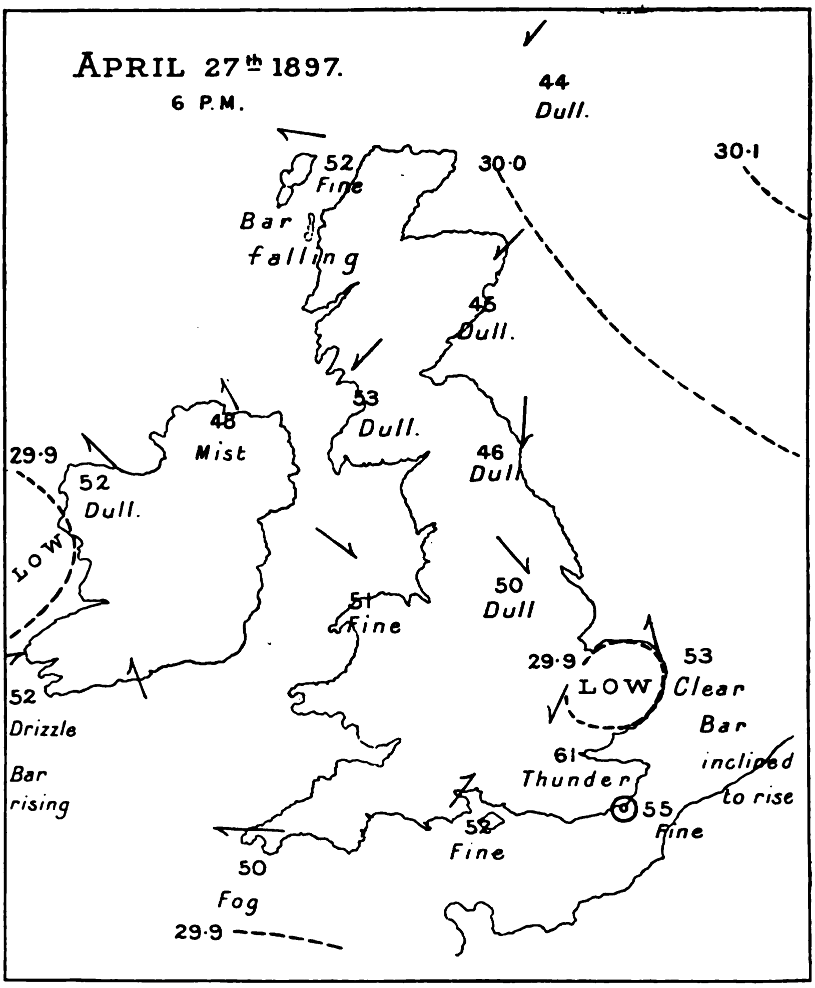

FIG. 1.

Mr. H. Wilkins, the Secretary of Lambeth Waterworks, in writing to me, says:—

> Our rainfall at the Lambeth Waterworks, Brixton Hill, taken at 10 a.m. on April 28, measured 0·94 in., as the fall for the twenty-four hours. From personal observation I can say that the fall of hail was very much greater at the eastern end of Christchurch Road than even about the middle; and as far as I can learn, the greatest fall of hail in this neighbourhood occurred on Streatham

Hill, between Telford Avenue and a little to the south of Christchurch Road. It was like walking on a pebbly beach, the hailstones being both large and solid. In my garden, at Christchurch Road, the hail accumulated in one corner (northward) to a considerable depth, and had not entirely disappeared at 3 p.m. the following day, although facing south-east and exposed to a certain amount of sun. The accumulation was apparently due partly to the hail rolling off the conservatory roof and partly to wind-drift.

A friend of mine, Mr. C. D. Davis, M.R.C.S., who resides at Cumberland Lodge, Streatham Hill, at the corner of Christchurch Road, amply supports Mr. Wilkins as to this spot experiencing the worst part of the hailstorm. Mr. Davis watched the progress of the storm, and in detail his experience was very much the same as my own, while vegetation with him suffered similarly.

The full violence of the storm was felt in parts of Tooting, and the banks of the London, Brighton, and South Coast Railway skirting Tooting Common were completely covered with hail the next morning, and patches of hailstones were still remaining on the Common the following evening (28) where protected by the gorse.

Mr. C. E. Fowler, who resides at Montrell Road, Streatham Hill, has sent me the following:—

> Referring to the hailstorm, the gist of the matter appeared to me the prolonged nature of the fall of hail, and the unusual size of the stones; many of them seemed to be as large as small marbles. They lodged in heaps on the slates of the houses, and then came down in masses with a thud, as though a man stood on the roof and sent them down with a shovel. They took a long time to melt, I could pick them up in handfuls two hours after the storm was over, and had no difficulty in filling the palms of my hands at 8.30 *the next morning* from stones lying on a heap of grass. Things in my garden, such as hops, phloxes, evening primroses, are practically destroyed, being denuded of leaves, and the top leading shoots cut off.

Mr. H. Wilkins, Secretary of the Lambeth Waterworks, has sent me the following statements made by the foremen in their districts to the east of Wimbledon:—

> Mr. Fox, Clapham Park.—At home at the time of the storm, which was very heavy, both rain and hail.
>
> Mr. Godfrey, South Wimbledon.—At South Wimbledon and Tooting Common the storm was very heavy, both rain and hail. On Tooting Common the storm was especially severe, the Common being covered with hailstones the next morning.
>
> Mr. Wilcher, Rockhill, Sydenham (close to Crystal Palace).—At home at the time of the storm, which was only an ordinary thunder and rain storm, nothing exceptional. Heard it was very severe at East Dulwich.
>
> Mr. M'Neil, Lower Sydenham (Bell Green).—At home at the time of the storm, and had only a slight shower of rain.
>
> Mr. Jones, Surrey Square, Old Kent Road.—At home at the time. Storm of hail and rain heavy, but not exceptional.

Symons's Monthly Meteorological Magazine for May contains the following very interesting letter from Mr. D. W. Horner, Clapham Park:—

> The storm of April 27, having apparently been peculiar to this locality, I venture to think that some notes upon it may be of interest to you. Commencing at 6.30 p.m., the hail fell so thickly that the ground was soon covered

to a considerable depth, bearing a resemblance to a heavy snow-fall. A great deal of damage accrued to fruit trees, the partly set fruit of the pear and plum being cut off completely, and early rose trees stripped of leaves and buds. The hail was followed by heavy rain, which being unable to escape down the gutters and drains through the mass of hailstones which choked them, flooded the houses, doing not a little damage. The hailstones were of a large size and diverse shapes, one which I picked up measuring half an inch square, but being soft they did little damage to glass. The storm lasted one hour, and on measuring the rain at its conclusion the amount in the gauge was found to be 1·18 ins. I am informed by an old inhabitant that it is necessary to go back to August 1846 for a parallel hailstorm in this neighbourhood. You will probably receive many letters on the subject, and it will be interesting to note how far the storm extended, as, from what I can gather, the area affected by it was very small, and the rainfall very variable, even within that limit.

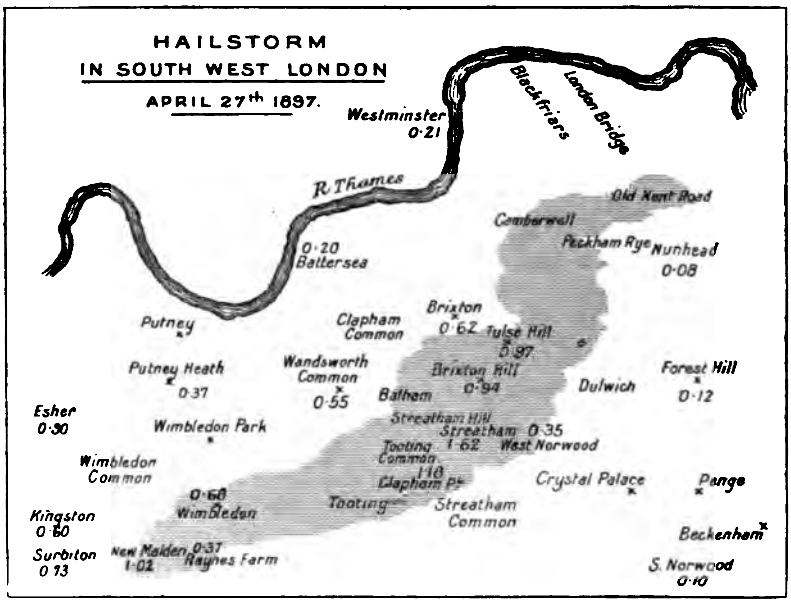

FIG. 2.

The following rain-measurements show how very local the storm was—the amounts are for the 24 hours ending 8 or 9 a.m., April 28. H is prefixed to the name of the station where hail was known to have occurred:—

		in.
H	Streatham (Woodfield Avenue)	1·62
H	Clapham Park (New Park Road)	1·18
H	New Malden (Sewage Works)	1·02
H	Tulse Hill (Brixton end)	0·97
H	Brixton Hill (Lambeth Waterworks	0·94
	Surbiton (Seething Wells)	0·73
H	Wimbledon (Sewage Works)	0·68
	Brixton (Acre Lane)	0·62
	Kingston	0·60
	Wandsworth Common	0·55
	Putney Heath	0·37
	Raynes Park	0·37
H	West Norwood	0·35
	Thornton Heath	0·28
	Richmond	0·27
	Westminster	0·21
	Battersea	0·20
	Croydon	0·16
	Forest Hill	0·12
	South Norwood	0·10
	Bromley	0·08
	Nunhead	0·08
	Greenwich Observatory	0·07
	Bickley	0·06
	Eltham	0·05

The limit of the hailstorm was very sharply defined, and this is very clearly shown by the accompanying diagram (Fig. 2). Although at Tulse Hill we experienced the full effect of the storm, there was no hail at Acre Lane about a mile farther north. The hail was very sharp at Tooting and Balham, but none fell at Wandsworth Common. The hailstorm was very severe at the top of Streatham Hill, close to the Free Library, but there is said to have been no hail at Streatham Common, which is slightly farther to the south. There was neither rain nor hail at the time of the storm at Sydenham, Beckenham, or Croydon.

A weather map for the British Islands is given for 6 p.m., April 27 (Fig. 1, p. 300), and from this it is seen that there was a shallow area of low barometer in the vicinity of London.

NOTE.—Mr. F. Jordan, of Claremont, Woodfield Avenue, Streatham Hill, in a letter to Mr. Symons, said:—

Between 6 and 7 p.m. on Tuesday, April 27, an extraordinary hailstorm, preceded and accompanied by vivid lightning and heavy thunder, raged in this locality. The hailstones fell in enormous quantities, and were about the size of marbles or filbert nuts. The quantity of rain falling was too great to be carried away by the sewers, which were no doubt choked to a large extent by the hailstones, and the low-lying ground was consequently flooded. Tooting Bec Common was practically under water for some hours, and even at ten o'clock on the following morning the water had not wholly subsided; and considerable streams were even then to be seen flowing across some of the pathways, and large patches of hailstones (some at least three inches deep) were still lying in places. Great damage was done to fruit trees in the neighbourhood, the blossom being thoroughly stripped off. The total quantity of rain measured the next morning in my gauge was 1·62 ins.

DISCUSSION.

The President (Mr. E. **MAWLEY**) said that Mr. C. Harding had given a complete account of this hailstorm. From the description of the damage to plants, shrubs, etc., he was exceedingly glad that it did not occur anywhere in the vicinity of his own garden.

Mr. F. C. **BAYARD** said that with regard to the amount of damage to vegetation wrought by the storm, he thought it possible that the severe frosts of May 12 and 13 were responsible in some degree for this.

Mr. W. **MARRIOTT** said that, at his station at West Norwood, some hail fell from 6.48 to 6.52 p.m. Thunder was first heard at 5.45 p.m., and the rain commenced at 6.30 p.m. and continued to 7.15 p.m. It would have been interesting if Mr. Harding had included some observations on the direction of the wind. A reference to the records of the Greenwich anemometer for that day showed that the wind was light or calm during the afternoon, but shifted suddenly to South-west from about 6.45 to 7.15 p.m. He would have liked to have seen the disturbance studied with regard to the contour of the districts over which it traversed, as he believed such storms usually followed the lowest levels. It was certain that there must have been a very steep vertical gradient of temperature when it was considered that the temperature in London at 6 p.m. was 61°, and the formation of hail required a temperature below 32°.

Mr. G. J. SYMONS said that to get a definite outline of a storm it was usually necessary to have a large number of observations, and Mr. Harding had succeeded very well. This had been his (Mr. Symons's) difficulty in an inquiry into a storm occurring at Seaford, Sussex, on May 30, which, as far as size of hailstones went, was far more severe than the one under discussion, some stones weighing 3 ozs., and others probably more. He thought the suggestion of Mr. Marriott with regard to the study of the storm in connection with the topographical peculiarities of the neighbourhood desirable and interesting.

Mr. R. INWARDS remarked that a noticeable feature of the storm was that it followed in an almost parallel line the course of the Thames.

Hon. F. A. R. RUSSELL thought that greater detail with regard to direction of wind would be an acquisition to the paper.

Mr. C. HARDING, in reply, said that with regard to what Mr. Bayard had said of the frosts of May 12-14 playing a part in the destruction of leaves, etc., he (Mr. Harding) on those dates had registered nothing lower than 33° in the air and 28° on the grass, which he did not think could seriously affect vegetation. With reference to the direction of the wind during the storm, a decided change from South to North took place, though the wind was extremely light all through. A dense fog set in after the storm.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 19, 1897.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

WILLIAM LEIGHTON JORDAN, F.R.G.S., Assoc.Inst.C.E., 25 Jermyn Street, S.W., was balloted for and duly elected a Fellow of the Society.

The following communications were read:—

"THE RAINFALL OF DOMINICA, WEST INDIES." By C. V. BELLAMY, F.R.Met.Soc., Assoc.M.Inst.C.E. (p. 261).

"MEANS OF THE DAILY MINIMUM, DAILY AVERAGE, AND DAILY MAXIMUM TEMPERATURES OF THE BRITISH ISLES, 1871-95." By R. H. SCOTT, F.R.S., and F. GASTER, F.R.Met.Soc. (p. 275).

June 16, 1897.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

CAPTAIN DAVID EDMUNDSTONE JAMIESON, 234 Portway, West Ham, E., was balloted for and duly elected a Fellow of the Society.

The SECRETARY read the following Address which the Council had resolved to present to Her Majesty the Queen on the Diamond Jubilee of her accession to the Throne :—

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MOST GRACIOUS SOVEREIGN,

We, Your Majesty's most dutiful and loyal subjects, the President, Council, and Fellows of the Royal Meteorological Society, hereby desire to approach and humbly offer to Your Majesty our heartfelt congratulations on the completion of the sixtieth year of your most prosperous reign.

In thus addressing Your Majesty, we feel that we only express sentiments which all the different classes and races of your subjects throughout the Empire share with us, and which in this year of Diamond Jubilee have prompted them mutually to encourage and foster such closer union, as shall consolidate and thereby strengthen the vast Empire over which your beneficent sovereignty extends.

That Your Majesty may be long spared to your Family, to this Nation, and to the Empire, is the devout wish and prayer of Your Majesty's devoted subjects, the President, Council, and Fellows of the Royal Meteorological Society.

Given under the Seal of the Society this Sixteenth Day of June, in the Year of Our Lord One Thousand Eight Hundred and Ninety-Seven.

EDWARD MAWLEY, *President.*
G. J. SYMONS, } *Secretaries.*
FRANCIS CAMPBELL BAYARD, }

Seal.

The following communications were read :—

"THE NON-INSTRUMENTAL METEOROLOGY OF LONDON, 1713-1896." By R. C. MOSSMAN, F.R.S.E., F.R.Met.Soc. (p. 287).

"HAILSTORM IN THE SOUTH-WEST OF LONDON, APRIL 27, 1897." By CHARLES HARDING, F.R.Met.Soc. (p. 298).

CORRESPONDENCE AND NOTES.

Note on Maximum Thermometers.—In common with most meteorological observers of the present day, I use maximum thermometers of the type invented by Messrs. Negretti and Zambra. After using these instruments for some time I found them behaving in an apparently peculiar manner when subject to considerable variations of temperature. At my station, situated near Melbourne, variations of from 30° to 40° within 24 hours take place occasionally during the summer months; as, for example, when the wind changes to the South after having been Northerly for a few days. Several times during such weather I had examined the maximum thermometer during the hot day, and also on the following morning when taking my usual morning readings. I was at first astonished to find that on these occasions the thermometer read about half a degree lower in the morning than it had done on the previous day; and could find no mention of such a difference referred to in any text-books. A little thought, however, showed that the difference was caused by the contraction of the mercury in the tube, due to the general lowering of temperature, and a table of the necessary corrections was easily computed which made the readings perfectly consistent.

As maximum thermometers are generally tested under conditions which render it certain that the mercury in the bulb and stem are at the same temperature, the corrections given in the Kew certificates will only apply to readings taken under the same circumstances. When the maximum thermometer is read with the air temperature 20° or 30° lower than that given by the thermometer in question, the contraction of the mercury in the stem must be allowed for if the true highest temperature is to be obtained. The amount of the correction will depend upon the position of the constriction in the tube, and its sign is always positive. The amount may be estimated approximately from the table herewith calculated for one of my thermometers in which the constriction is at – 14°.

Corrections for Contraction of Mercury in Stem.

Max. Temp. Recorded.	Temperature of Air when Max. Thermometer is read						
	100°	90°	80°	70°	60°	50°	40°
110°	+0°·1	+0°·25	+0°·4	+0°·5	+0°·6	+0°·75	+0°·9
100	...	+0·1	+0·2	+0·3	+0·5	+0·6	+0·7
90	...	...	+0·1	+0·2	+0·3	+0·4	+0·5
80	...	...	...	+0·1	+0·2	+0·3	+0·4
70	...	...	...	...	+0·1	+0·2	+0·25
60	...	...	...	...	...	+0·1	+0·2

No doubt similar corrections should be applied in the case of solar maximum thermometers, but in view of the generally wide variations amongst these instruments, it would probably be an unnecessary refinement. It may be noted, however, that the mercury in the tubes of these instruments will be at a lower temperature than that in the bulbs, so that there will always be a tendency for them to read somewhat low.—THOMAS WALKER FOWLER, Assoc.M.Inst.C.E., F.R.G.S., Melbourne University.

Death by Lightning.—The effects of lightning as it passes to earth through the body of a man vary within an astonishingly wide range. It sometimes happens that a person is killed outright without any symptoms or sign of injury. It may be that death is preceded by collapse, paralysis, or convulsion; usually there are marks where the current has entered or left the body, or clothes may have been scorched, or hæmorrhages may have occurred, and more than one case has been recorded where boots have been torn off the feet and nails driven out of the soles of the boots. Seldom does it happen that lightning leaves such appalling evidence of its transit as that disclosed at an inquest held at Hulford House, near Guildford, on Saturday, August 28, 1897. The evidence showed that on the previous Wednesday there had been a single flash of lightning and a clap of thunder, and about half an hour afterwards Major Jameson was found lying on his face in a field, quite dead. Around him, in a radius of several yards, were his clothes and boots, which had been torn and scattered about in an extraordinary manner. The lightning appears to have struck him on the right side of the head, tearing his cap to pieces and burning his hair off. It then passed inside his collar down the front of his body and both legs into his boots, which were torn to pieces, and then passed into the ground, making a hole about eighteen inches in circumference and three inches deep. His collar was torn to pieces, the front of his shirt was rent into ribbons, the jacket and under-vest were literally torn to shreds, and the knickerbockers he was wearing were stripped from him and scattered on the ground. His stockings and gaiters were similarly torn in pieces, and on the boots the lightning had a remarkable effect. They were burst open, some of the brass eyelet-holes were torn out, nails were forced out, and the soles torn off. The skin had been torn off the chest, and the right leg was torn and blackened; blood was issuing from the mouth and right ear. In connection with this fatality, two circumstances of a more or less unusual kind may be noticed. There is, first, the single lightning flash, neither preceded nor followed by others in the neighbourhood; and, secondly, the fact that the person who was struck was "in the open." The latter comparatively seldom happens, perhaps because shelter is instinctively and perhaps unwisely sought. Here there was no warning and no time for this, and so, without any neighbouring object at hand to sub-divide and share the discharge, the latter had only one route to earth—viz. the body of its victim. The wet or dry condition of the clothes is an important point in such cases. It often happens that in persons exposed to a thunderstorm the clothes are wet, and therefore afford a comparatively easy passage to any electric current. In the case above detailed the clothes were presumably dry, and therefore bad electrical conductors, and the destructive effect of the lightning would be in proportion to the resistance encountered in transit.—*The Lancet.*

Globular Lightning.—According to the *Zeitschrift für Elektrotechnik*, August 15, this unusual and interesting phenomenon was observed at the watering-place, Szliács, on May 25. About noon on that day a violent thunderstorm broke over Szliács. At 2.45 a ball of lightning about the size of a man's head was seen to descend, and float about 6 feet above the ground. It whizzed past the stair railings of the "Villa Buda," throwing a workman, who was standing near, against the pillars which support the steps. It then passed through an open window into a room on the ground-floor, passed within a few paces of the bath superintendent sitting at a table, and close by a porter standing in the room, then out into the open again through a closed window, in which it cut a hole about the size of a fist. When outside, the lightning ball struck a poplar standing 15 paces in front of the building. From this it tore off the bark and wood to a depth of 2 cm., a breadth of 20 cm., up to a height of 10 metres, whence it descended on the other side to the earth, leaving behind it a narrow channel. The detonation which accompanied the lightning was not louder than the report of a gun. Nobody was injured. Another case is reported from Nioheim, in Prussia. A lightning discharge, accompanied by crashing thunder resembling the discharge of a mass of broken glass on the pavement, struck a farmhouse near the station. The following peculiarities in the appearance of the lightning were noted by six eye-witnesses. It descended from the cloud to the outside of the chimney in the form of a ball, about the size of a cannon ball. After the ball was an interval of 1 to 1½ metres, then a discharge in the form of a bundle of rays, so large that a man could scarcely have encompassed it with his arms, of 1 to 2 m. in length. The ball appeared to be accompanied by a short sharp report, while the crashing thunder appeared to be due to the discharge.—*Electrical Review.*

The most Rainy Part of England.—In *British Rainfall* for 1895, Mr. Symons dealt fully with the rainfall of Seathwaite, where records have been kept for more than fifty years. In *British Rainfall* for 1896, Mr. Symons has discussed the rainfall records from the stations in the neighbourhood of Seathwaite, which includes the most rainy part of England.

Dr. J. F. Miller, F.R.S., started some rain-gauges which were recorded monthly from 1847 to 1853. The work was resumed and extended by Mr. J. Fletcher, M.P., F.R.S., in 1863, and was subsequently carried on by Mr. J. Maitland and others.

The "reduced" or average annual rainfall, for the stations at which any records were kept during the period 1864-1896, is as follows :—

	Altitude. ft.	Rainfall. ins.
Scaw Fell	3200	94
Scaw Fell Pike, Broad Crag	3010	114
Esk House	2550	85
Great End	2982	66
Sprinkling Tarn	1985	123
Brant Rigg	695	77
Gabel House	1077	84
Stye Head Tarn	1472	123
The Stye, Gauge B	1077	179
,, ,, C	1077	184
,, ,, D	1077	163
Taylor's Gill	1077	164
Seathwaite	422	135
Stonethwaite	350	101
Borrowdale Vicarage	330	104
Rosthwaite	305	105

The influence of position with respect to hills and valleys is far greater than that of altitude.

The Stye is really a strip of nearly level ground about 200 yards long and 30 yards wide, running from north-west to south-east, on the north-east slope of a hill, but not on a precipitous part thereof. The rainfall varies considerably from year to year: six times it has exceeded 200 inches, viz.

1866	224·56 ins.	1872	243·98 ins.	1882	202·50 ins.
1868	207·49 ,,	1877	235·52 ,,	1890	202·05 ,,

The least amount in one year was 99·16 ins. in 1855.

"Waterspout," "Cloudburst," or "Tornado."—These three terms are often used indiscriminately when it would be easy to make a clear distinction between them. The *Cleveland World* of April 1 reports that "a waterspout on March 31, at Pana, Ill., threw a train of five cars and engine from the track of the Illinois Central." It does not appear likely that the damage here mentioned was done by wind; we may therefore infer that we have not to do with a tornado. A waterspout at sea is, according to all established usages in the English language, a different phenomenon from a heavy rain. Rain often accompanies a waterspout, but is not the prominent and characteristic feature. In the present case there could have been no waterspout, properly speaking, because the phenomenon occurred over dry land of the interior of the continent. The daily weather-map shows that the conditions were favourable for the formation of severe rains, thunderstorms, cloudbursts, and possibly tornados over Illinois on the afternoon of March 31; in fact a tornado was reported in Arkansas, but not waterspouts properly so called. The use of the word "waterspout" when the writer really means only a heavy rain and wind, is not to be recommended. Such rains and winds are characteristic of thunderstorms and so-called "cloudbursts." In the present case it is likely that rain did not alone do the damage that is reported; a flooded track and a strong current of water would be needed to throw an engine from the track, or possibly the flood caused by the rain had undermined the track and thus indirectly caused the derailment. In general, in such cases as this it would be more proper to omit the words "waterspout" and "cloudburst." If the train was thrown from the track, or lifted from the track, as the headlines of the above article had it, this must have been due to a severe storm, but certainly not to a "waterspout" properly so called.—*Monthly Weather Review*, May 1897.

RECENT PUBLICATIONS

Annales de l'Observatoire National d'Athènes. Tome I. 4to. 1897.

This contains a monograph of the Climate of Athens, by Prof. Démétrius Éginitis, the Director of the Observatory. The subject is most elaborately worked out, and extends to 220 pp. He quotes copiously from the classic authors, Plato, Aristotle, Pausanias, and others, and strongly maintains the idea that Attica has always been as arid as it is now. As regards the question of change of climate, he cites the instance of the date palm, which now is unable to ripen its fruit to perfection, though occasionally the dates are sweet enough to be edible. Prof. Éginitis shows that the same conditions were reported by Theophrastus and Strabo.

Journal and Proceedings of the Royal Society of New South Wales for 1896. Vol. XXX. 8vo. 1897.

Contains the following meteorological papers:—On periodicity of good and bad seasons: by H. C. Russell, F.R.S. (31 pp. and plate). In this paper the author endeavours to show that droughts recur in cycles of nineteen years.—Current Papers, No. 2: by H. C. Russell, F.R.S. (9 pp. and plate).—*Re* Notable Hailstorm of November 17, 1896, in parts of parish of Gordon: by E. Du Faur (8 pp. and plate). During this storm the hailstones perforated the corrugated iron on a verandah. The hail in some places lay 3 feet deep on the level, and 7 feet deep by hedges.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. June–September 1897. 4to.

The principal articles are:—Beobachtungen und Experimente am Variometer über den Zusammenhang von Erniedrigung des Luftdruckes und starken Blitzen, bezw. elektrischen Entladungen: von O. Rosenbach (9 pp.). This is an account of the performance of a new apparatus called a "variometer," invented by Herr v. Hefner-Alteneck. The apparatus is designed to measure the very slightest oscillations of pressure; and Dr. Rosenbach shows that it is such variations of pressure, quite imperceptible on a mercurial barometer, which are the probable causes of cold-catching and other affections of the human organism. The author goes on to show the connection between these instrumental indications and individual flashes of lightning, as a distinct reduction of pressure appears to accompany each flash. Violent flashes of lightning are preceded by a reduction of pressure, but at the instant of the flash a recovery appears. This phenomenon could be reproduced by a powerful electrical machine. It is evident that reductions of pressure correspond to increases of electrical tension, and the two phenomena are complementary to each other. These oscillations of pressure are not accompanied by ordinary wind, but are analogous to the phenomena of electrical winds.—Vergleichung der Barogramme von einigen Orten ringsum Wien: von M. Margules (13 pp.). This is a comparison of four Richard barograms, situated at distances of nearly forty miles from Vienna, and fairly distributed round the city. It is interesting to see the minute changes that the several curves exhibit; but Dr. Margules points out that in order to explain the phenomena clearly, many more barograms will be needed, and those from stations nearer to each other and to Vienna.—Das Klima Astrachans nach F. Schperk: von A. Woeikof (9 pp.). Dr. Woeikof gives an abstract of this paper, which appeared in Russian in *Sapiski der k. Russischen geographischen Gesellschaft*, vol. xiv., under the title of "Russia in the Far East." The account of Astrachan gives a clear view of the comfort of living there. In winter the setting in of winds from the Caspian forms ice-blocks rivalling the experiences of Nansen, or even the palæocrystic ice of Nares. In summer the heat is intense. The range of temperature for forty-four years gives minimum – 26°, maximum 109°·4, the extreme range is therefore 135°·4 ! ! The weather is governed by the anti-cyclones of Turkistan. Statistics of the ice of the river and lake are also given. The climate is naturally exceedingly dry. The relative humidity is 72 per cent, but a reading of 11 per cent has been noted. Winter lasts 96 days, Spring 50 days, Summer 145 days, and Autumn 74 days.—Die periodische Wiederkehr kalter und warmer Sommer: von Dr. J. Maurer (7 pp.). This is an attempt to forecast the character of the seasons for the beginning of the twentieth century, much on Brückner's lines; and the author concludes by saying that he expects for the beginning of the next century a succession of warm summers with occasional mild winters.—Messungen des Potentialgefälles der Luftelektricität in Ladenburg a. Neckar: von Dr. A. Gockel (17 pp.). This paper offers many points of interest to the few who work at atmospheric electricity. We may point out that the author finds that Braun's statement, that phenomena are related to the phases of the moon, is not confirmed; and the same may be said of Exner's announcement of a direct relation between the potential and the vapour tension. A very remarkable fact is pointed out which Dr. Gockel promises to investigate further, viz. that at the moment of sunrise the leaves of the electroscope suddenly fly asunder. This does not occur always, and appears to be most marked when there is strong hoar frost.—Untersuchungen über die jährliche Periode der Windgeschwindigkeit: von Dr. G. Hellmann (19 pp.). This is a discussion of the anemometrical results of which mean values, for at least ten years, are printed, all over the world. It is prefaced by some remarks on anemometer exposure. Monthly figures are given for about 200 Robinson anemometers, for 17 pressure plates, and for 35 Wild's pressure plates. The general results are summarised as follows:—1. The velocity increases with increase of latitude, and decreases from the coast into the interior. 2. The maximum in high latitudes, and at coast stations lying to windward, occurs in winter. At inland stations it is noticed between March and July. 3. The occurrence of maximum coincides with the maximum frequency of storms. 4. The minimum at such inland stations as have a spring maximum occurs in August or September, but at coast stations with a winter maximum it occurs in June or July. 5. The amplitude of change is greater on the coast than inland, but greatest in regions with strong periodical winds (monsoons). The paper concludes with an attempt to connect the changes in wind velocity with changes in pressure and in temperature. The latter seems more promising than the former.—Meteorologie und Erdmagnetismus in Finnland (9 pp.). This is a summary of a paper by MM. Heinrichs und Bise, read at the Geographical Congress in London 1895, giving a history of all the several series of observations in Finland which were set on foot by Linnaeus in 1753.

Story of the Earth's Atmosphere. By Douglas Archibald, M.A. Sm. 8vo. 1897. 208 pp.

This is one of a series of little books published by George Newnes, Limited. The object of the author has been to put forward the main features of our knowledge of the conditions which prevail in our atmosphere as they are interpreted through the science of to-day. The book has been written, not for the minority, who vaguely wonder at the relation of extraordinary facts and pass on, but for the much more numerous section who are not content with a mere collection of facts, but want to know the reason why.

Symons's Monthly Meteorological Magazine. July–September 1897. 8vo.

The principal articles are :—The storm of June 24, 1897 (11 pp.).—Recent Storm-rains (3 pp.).—Fromondus and his notes on the weather (5 pp.).—Climatological records for the British Empire in 1896 (3 pp.).—High temperature on the night of August 4 (2 pp.).—Notes of damage by rain and thunderstorms (3 pp.).

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